MOJAVE NATIONAL PRESERVE

CALIFORNIA

WATER RESOURCES SCOPING REPORT

Mojave National Preserve
and
Water Resource Division

In cooperation with

Department of Earth Resources
Colorado State University

Technical Report NPS/NRWRD/NRTR-99/225

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WATER RESOURCES SCOPING REPORT

MOJAVE NATIONAL PRESERVE

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Water Resources Division
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in cooperation with

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WATER RESOURCES SCOPING REPORT
MOJAVE NATIONAL PRESERVE
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ABSTRACT

This report presents an overview of the water resources, watersheds, and principal water-related issues in the National Park Service's Mojave National Preserve. The Preserve, which is located in San Bernardino County, Southern California and totals nearly 1.6 million acres, provides for the preservation of natural and cultural resources, outdoor recreation, and appreciation of the California desert. The mountains of the Preserve also contain the headwaters of major desert watersheds, which are the areas where ground-water recharge occurs.

The report provides a summary of common meteorological data for the area, including precipitation, humidity, evaporation, and temperatures. The principal hydrologic basins are described, discussing the processes of surface and ground-water flows, flooding, and aquifer recharge. Details are given on the springs, seeps, and guzzlers (artificial water catches) in the Preserve, describing locations of these water features and discussing flow and water quality.

An overview of wells is presented, listing the numbers of wells, and discussing well yields, depths to water table, and quality of the ground water, with tables of data or summary lists included as appendices.

Information is provided on key sources of information, agency programs, literature, and relevant expertise related to water resources and water issues in the area, providing names of key individuals.

Water resource issues in the area are discussed, including: mining activities and their water demands and potential water quality impacts; the possible deleterious effect of development at the Preserve's periphery on the springs and wells in the Preserve; the concern of attaining and protecting water rights for the Preserve; possible contamination by hazardous wastes; flooding at selected sites where resources or structures could be at risk of flash floods; how to manage guzzlers within the context of a wilderness area; and the questions of exotic vegetation and animals and their impacts on riparian zones or seep areas.

Recommendations are presented, to flag the issues which should be of concern to the Preserve and to suggest ideas or follow-up work to tackle certain problems or to collect needed information. Draft proposals (project statements) are presented for six project ideas.

PREPARERS OF THE REPORT

This report was prepared by Sam Kunkle, Faculty Affiliate of the Department of Earth Resources, Colorado State University,[1] working in close in conjunction with the natural resource staff of the Mojave National Preserve, especially Gordon Reetz, Natural Resource Specialist.

Jeff Hughes and Dan McGlothlin of the National Park Service's Water Resources Division provided major inputs for the water rights section of the report. Matt Hagemann and Mark Flora, also with the Water Resources Division, assisted with technical advice and other suggestions.

Don Ebert, Environmental Protection Agency, Las Vegas and Dennis Schramm, Planning Team Leader at Mojave NP, prepared the color graphics and advised on maps and other information. The black and white graphics and photographs were by the principal author.

Tom Bilhorn, Consultant, assisted with recommendations for networking and information gathering.

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WATER RESOURCES SCOPING REPORT
MOJAVE NATIONAL PRESERVE [2]

1. INTRODUCTION

1.1. OVERVIEW

Mojave National Preserve is located in the eastern Mojave Desert of Southern California, with its northeastern boundary along the California-Nevada state line (Figure 1.1). Its area totals nearly 1.6 million acres, making it the third largest park unit in the continental United States. About fifty percent of the Preserve is designated as wilderness (Mojave NP, 1998).

The Mojave National Preserve was established to:

- Preserve and protect the natural and scenic resources of the Mojave Desert, including transitional elements of the Sonoran and Great Basin Deserts;
- Preserve and protect cultural resources representing human use associated with Native American cultures and westward expansion;
- Provide opportunities for compatible outdoor recreation; and
- Promote understanding and appreciation of the California desert (Mojave NP, 1998).

Many mountain ranges are scattered throughout the Preserve, and peaks in the major mountain ranges stand some 2,000 to 3,000 feet above their adjacent valleys. Elevations in the Preserve range from about 1,000 feet to over 7,000 feet. The Preserve has many distinct geographic features, such as Cima Dome, Kelso Dunes, and Cinder Cone Lava Beds.

Land-use activities in the Mojave NP are diverse, and include mining, ranching, railroad lines, outdoor recreation, nature appreciation, hunting, trapping, environmental education, history appreciation, and natural resource research projects.

1.2. PURPOSE OF THIS REPORT

The 1998 draft General Management Plan (GMP) for the Mojave National Preserve listed objectives which relate specifically to water resources management, including the following:

- attain water rights should any private land be acquired;
- in general, use water efficiently and frugally;
- protect surface and ground waters;
- restore disturbed water resources to more natural conditions;
- emphasize protection of native plants and wildlife at water sites;
- treat any wastewater, to avoid pollution;
- in general, avoid inter-basin transfers;
- monitor impacts of activities along the boundary, to assess any impacts on the Preserve's water resources;
- take legal steps or other actions, if necessary, to protect the Preserve from impacts on water (Mojave NP, 1998).

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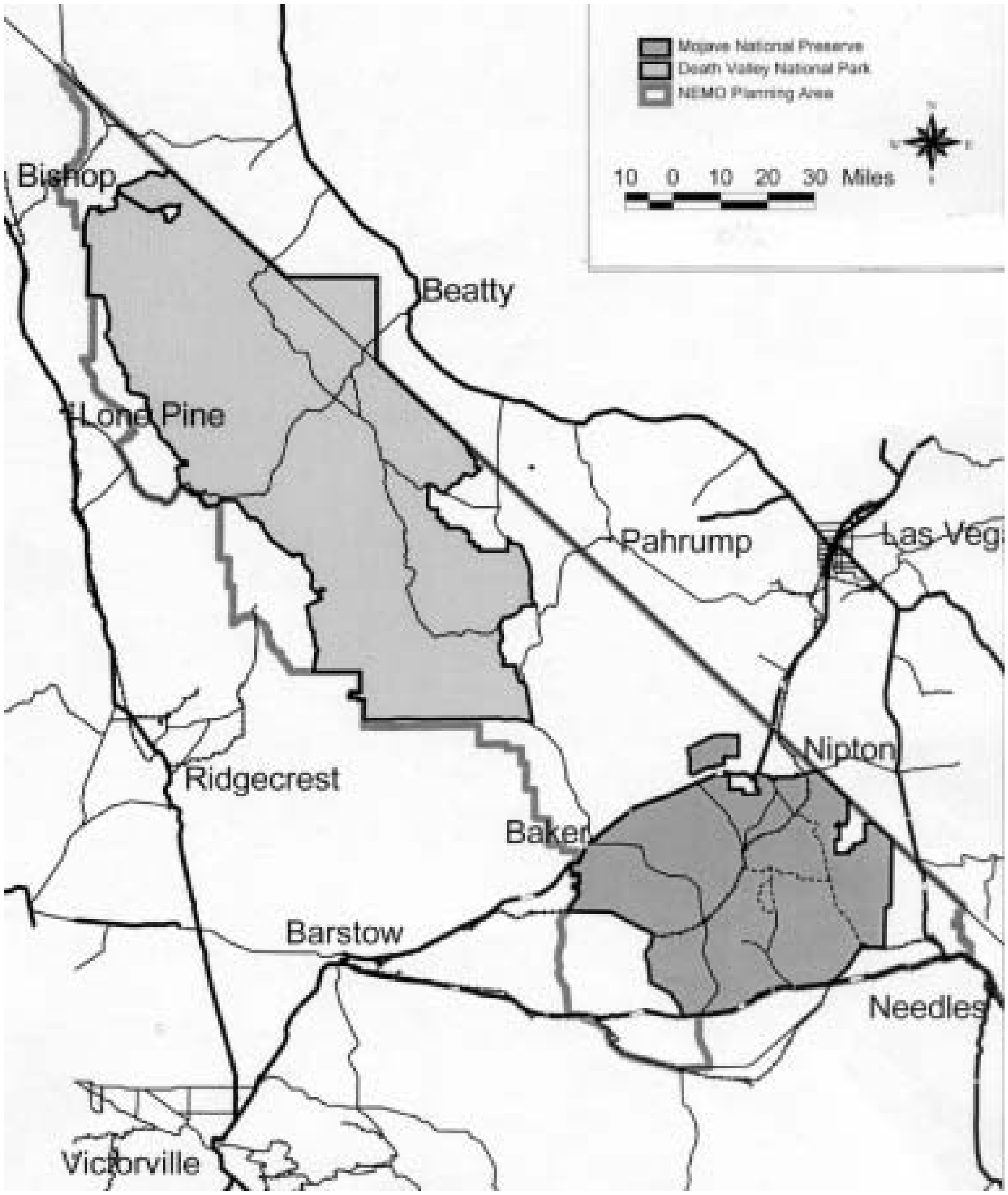

Figure 1.1. The location of Mojave NP and its proximity to towns and other features within the greater Mojave Desert area of California and Nevada.

The objectives of this Water Resources Scoping Report are complementary to the General Management Plan, seeking to:

- Provide a general overview of the water resources and watersheds within the Mojave NP;
- Summarize the principal water-related issues in the Preserve and its periphery, and help identify critical issues;
- List the principal sources of hydrological information and expertise in the area;
- Help identify what water resource information, monitoring, or data are needed;
- Identify needs for further technical assistance or possible cooperative research in the water resource area; and
- Assist the Preserve staff to develop proposals (NPS Project Statements) suitable to seek funding for projects on certain issues.

2. HYDROLOGIC, HYDROGEOLOGIC, AND CLIMATIC OVERVIEW

2.1. CLIMATE SUMMARY

The Mojave Desert is located in the rain shadow of 5000-11,000 foot mountains, to the west, which accounts for the area's arid to semi-arid climate. The precipitation in the Mojave Desert area occurs in two characteristic periods in the year. About two-thirds or more of the average annual precipitation occurs in the November through March winter period, when cyclonic, winter storms move in from the Pacific Ocean. These storms may last for several days. Winter precipitation in the higher mountains is sometime in the form of snow (Hall, 1981; Hardt, 1971; Prigge, 1996). Summer precipitation comes as short, intense, localized summer thunderstorms, in the monsoon pattern. Much of this summer rain is lost to evapotranspiration, especially for the smaller storms. Precipitation exceeds potential evapotranspiration (PE) only briefly, during about December through February. This is also the time when most ground-water recharge can occur(Hall, 1981; Thompson, 1929).

Table 2.1.a. Information from meteorological stations in or near the Preserve, from Rowlands, 1996 (Ppt = precipitation; ET = evapotranspiration).

Location	Elevation	Mean annual ppt	Potential ET	Summer ppt as % of annual
Needles, CA	278 m (912 ft)	111.8 mm (4.40 inches)	1263 mm (49.7 inches)	34.1%
Baker, CA	319 m (1046 ft)	86.2 (3.39 inches)	1250 (49.2 inches)	20.6 %
Mitchell Caverns, CA	1320 m (4330 ft)	227.1 (8.94 inches)	917 (36.1 inches)	30.0 %
Mountain Pass, CA	1442 m (4730 ft)	209.6 (8.25 inches)	801 (31.5 inches)	29.4 %

Length of records for the stations in Tables 2.1.a and b are: Needles –since 1940; Baker –since 1931; Mitchell Caverns –since 1958; and Mountain Pass –since 1958 (internet <www 4.ncdc. noaa.gov>).

There is great variation in precipitation for any given month during a period of years and for the annual average. Winter precipitation typically spreads over wide distances, whereas summer precipitation is localized. A summer storm may dump an inch or more at one site, while a few miles away no rain occurs. Precipitation data are extrapolations for most of the Preserve, and exact data generally are missing.

The further east one goes in the Mojave, the greater is the tendency for summer storms to occur, since they generally move in from the Arizona direction. Conversely, few summer storms occur in the western edge of the Mojave Desert (Thompson, 1920; Rowlands, 1996a; Prigge, 1996).

Precipitation amounts correlate strongly with elevation, ranging from about 4 inches annually in lower areas, such as Soda Lake, to over 12 inches annually in the highest elevations of the New York Mountains (Figure 2.1.). Presumably other peaks over 7,000 feet, such as in the Clark Mountain have over 12 inches as well; however, few permanent, long-term weather stations are found in mountain areas to confirm exact amounts. Note that the two higher elevation sites in Table 2.1.a have about twice the precipitation of the two lower ones (Environmental Solutions, 1989; Rowlands, 1996a).

The average relative humidity (annually) is less than 30 percent, and often the relative humidity falls below 10 percent during much of the day (Geoscience, 1995). The evaporation rate observed with a National Weather Service Class A evaporation pan is about 83 inches for a year at Victorville, at the western edge of the Mojave Desert. In other words, the potential evaporation (PE) is over an order of magnitude greater than the actual precipitation (Hardt, 1971). Modeling of evapotranspiration (theoretical calculations) by Geoscience Inc in 1995 estimated the potential evapotranspiration (PE) in the Preserve at 35 inches a year (This was for a weighted mean elevation of 4598 feet in the Providence Mountains, roughly in the center of the Preserve). In other words, the PE is approximately 3 times the 12 inches precipitation there. So even in the mountains, a large percentage of precipitation is lost to evapotranspiration.

Table 2.1.a. compares precipitation and PE data from stations in the general Preserve area. Long-term temperature and precipitation data are collected at Mitchell Caverns, inside the Preserve's boundary, at about 4,330 feet elevation in the Providence Mountains (Rowlands, 1996a-b, Schweich, 1998).

The water quality of precipitation was tested by Feth (1967), including two sites inside the Preserve, at the O-X Ranch and Kelso. He tested for calcium, sodium, potassium, magnesium, silica, sulfate, bicarbonate, chloride, nitrate, and specific conductance. The cations were all low --in the single digits. The specific conductances ranged from 11 to 218, with a median of 57 micromhos/cm, which indicates soft water with low inorganic concentrations. In some cases local dust may have contributed salt to the rain, he surmised.

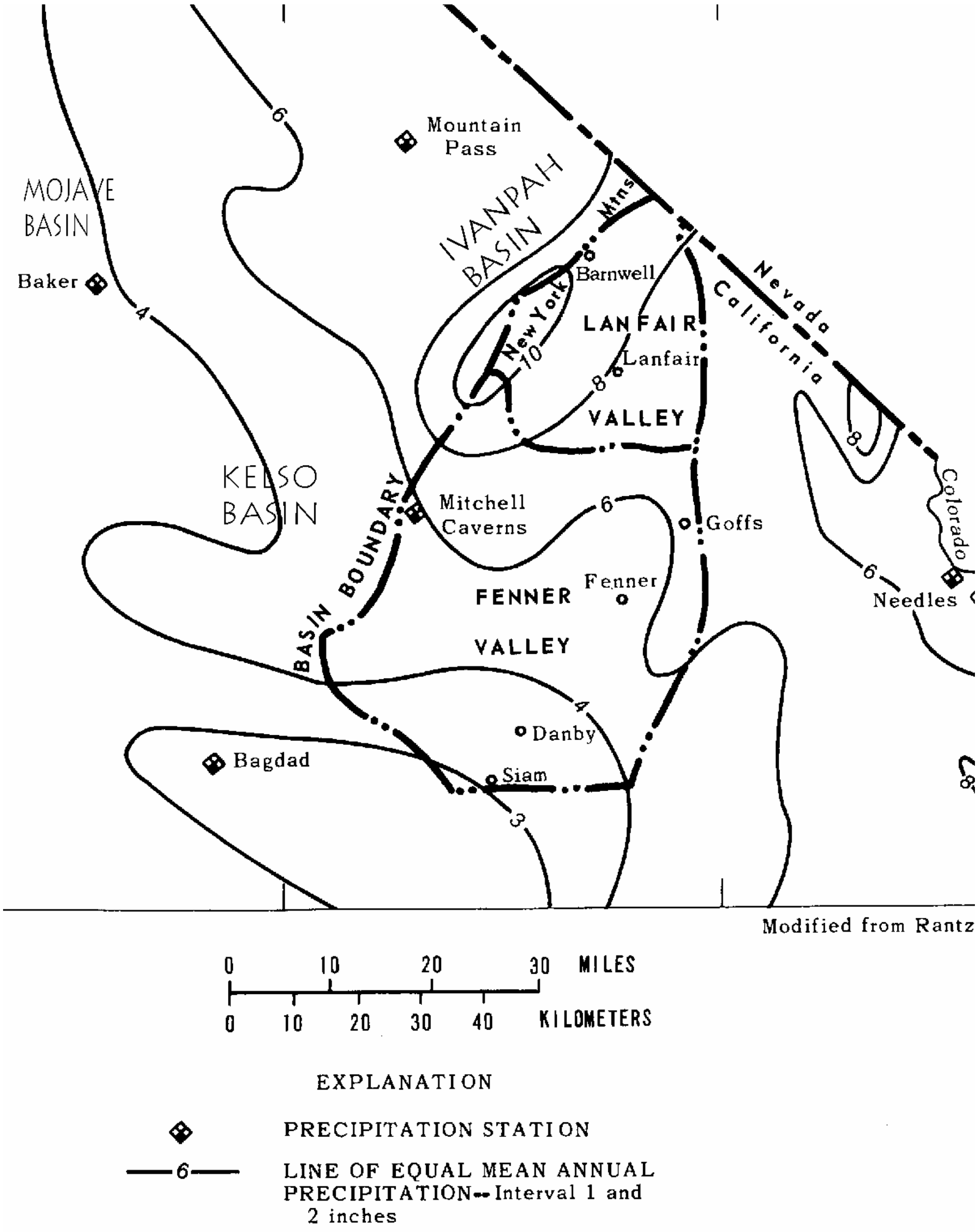

Figure 2.1. Precipitation in the Preserve area, from U.S. Geological Survey reports (Freiwald, 1984), showing isohyets of precipitation, with higher levels along the principal mountain range. Freiwald's "basin boundary" line also shows the main divide of the mountains and the upper Fenner and Lanfair basins.

Temperatures are variable, with extreme heat occurring at many sites, but winter freezing is also common in much of the Preserve. Table 2.1.b provides temperature data seen from the same four U.S. Department of Commerce meteorological stations used in Table 2.1.a. Note that other locations with some limited, past rainfall data include Kelso and the Ivanpah County Yard (Huning, 1978).

Table 2.1.b. An overview of temperatures (degrees centigrade). (Rowlands, 1996a).

Location	Comment	Mean Jan. minimum	Mean July maximum	Annual average
Needles, CA	E. of the Preserve	4.7 deg C	42.3 deg C	22.3 deg C
Baker, CA	N. edge of Preserve	0.9	42.9	21.6
Mitchell Caverns, CA	Inside the Preserve	3.1	42.2	16.9
Mountain Pass, CA	NE edge of the Preserve	-2.0	34.8	13.8

Vegetation is an excellent indicator of both temperature and precipitation patterns and can help in extrapolating climatic information in areas where data are lacking. Rowlands (1996a), now with the National Park Service in Arizona, conducted an extensive overview of climate and vegetation relations in the eastern Mojave Desert.

2.2. THE BASINS AND SUB-BASINS OF THE PRESERVE

This section provides a broad overview of the Preserve's main drainage basins and describes the general directions of flows. The references to basins and directions of flow include relatively shallow sub-surface waters as well as surface flows. As pointed out by Thompson (1929), "The principal source of ground water is the runoff from the mountains … when the mountain streams reach the alluvial slopes, their water generally sinks rapidly into the gravelly alluvium and percolates down to the water table."

Essentially all of the Preserve's watersheds have their headwaters within the Preserve, with three exceptions:

- a small NW corner of the Preserve where drainage from the Mojave River basin cuts across; and

- two NE areas where the Preserve's boundary excluded some mining areas upslope from the Preserve (near Mountain Pass and the Castle Mountains).

In the simplest terms, the drainage pattern in the Preserve breaks down as follows:

- All of the Preserve drains into *closed basins,* except for the Lanfair Valley to Piute Spring area, at the eastern edge, which drains toward the Colorado River. A small eastern edge of the Preserve drains into the Piute Basin, which is part of the Colorado River Basin.

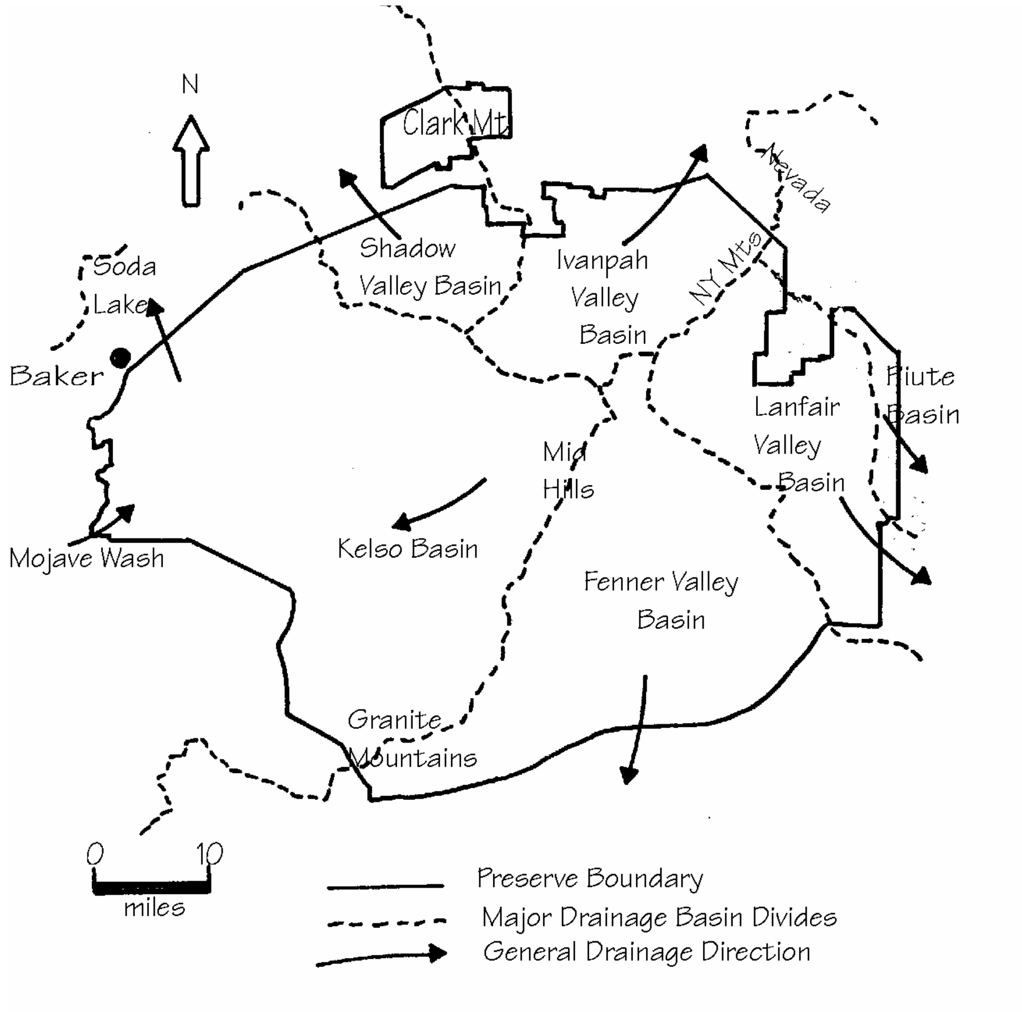

Figure 2.2. Major drainage basin divides and general directions of surface and ground-water drainage in the Mojave National Preserve.

The chain of Granite-Providence-New York Mountains bisects the Preserve into northern and southern components, from a hydrologic perspective, with the *South Lahontan Hydrologic Region* to the north and the *Colorado River Basin* to the south (Figure 2.2).

Drainage South Off the Major Mountain Divide : The southern flanks of the Granite-Providence -Mid Hills -New York Mountains drain into the State's *Colorado River Basin Region* as follows (Figure 2.2).

- The eastern/northern end of the New York Mountains drain south into the Lanfair Valley (USGS Hydrologic Unit Code (HUC) 15031002, the Lanfair-Piute Basin; State Hydrologic Area 713.40 and State Ground Water Basin (GWB) 7-1[3]), then into the Piute Valley and east into the Colorado River. Most water disappears underground, although the flow from Piute Springs, at the Preserve's eastern boundary, stays above ground for up to about a mile, as a perennial stream. A small eastern edge of the Preserve, at the Piute Mountains, drains east into the Piute, then the Colorado Basin (Freiwald, 1984; Thompson, 1929; Geoscience, 1995; Environmental Solutions, 1989). *General elevation ranges in this basin:* The upper mountain peaks lie at about 6,000 feet, while the lowest part of the basin *inside the Preserve* drops to at about 3,000 feet.

- The Providence- Mid Hills southern New York Mountains drain south into the Fenner Valley (USGS HUC 18100100; State HA 710.20; State GWB 7-2), disappearing underground in the direction of Cadiz and Bristol Dry Lake (Freiwald, 1984; Thompson, 1929; Geoscience, 1995). *General elevation ranges in this basin:* The upper mountain peaks go to over 6,000 feet, while the lowest part of the basin *inside the Preserve* drops to at about 2,000 feet.

- A very small corner on the far west edge of the Granite Mountains first drains south into Orange Blossom Wash, near Interstate 40, then into the greater Bristol Valley HA (State HA 710.10 or GWB 7-8), and eventually joins up with ground waters of the greater Fenner Valley (again in the USGS HUC 18100100), in the Cadiz area (Geoscience, 1995, CDWR, 1967a). *General elevation ranges in this small sub-basin:* Granite Peak sits at 6,762 feet, while the lowest part of the basin *inside the Preserve* drops down to at about 3,000 feet.

Drainage North Off the Major Mountain Divide: Waters draining the northern slopes of the Providence-New York Mountains flow northwesterly toward the Mojave River Wash and Death Valley direction, or northeasterly toward Nevada --all in the State's *South Lahontan Hydrologic Region,* (Figure 2.2).

- The northern slopes of the New York Mountains and the eastern end of the Mid Hills drain into the Ivanpah Valley (USGS HUC 160600215, Ivanpah Basin; State GWB Basin 6-30), then northeast toward the lower Ivanpah Valley, in Nevada (Moyle, 1972; Thompson, 1929). *General elevation ranges in this basin:* The upper mountain peaks lie at over 6,000 feet, while the lowest part of the basin *inside the Preserve* drops to at about 2,500 feet.

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[3] US Geological Survey Hydrologic Unit Codes (HUCs) from USGS, 1987 Hydrologic Unit Map and California Regional Water Quality Control Board, 1994; Ground Water Basins (GWBs) from California Dept of Water Resources, 1975.

- The NW slopes of the Providence Mountain and much of the SW end of the Mid Hills drain north into the Kelso Valley (State GWB 6-31) and the Kelso Wash, which is part of the greater Mojave River and Soda Lake Basin (USGS HUC 18090208; State GWB 6-33) (CDWR, 1975). Cornfield Spring, located upslope above the settlement of Kelso, has strong flow that produces a flowing stream for a short distance. *General elevation ranges in this basin:* The upper mountain peaks reach over 6,000 feet, while the lowest part of the basin *inside the Preserve* drops to a little less than 1,000 feet.

- The Ivanpah and Clark Mountains, at the northern point of the Preserve, essentially split the flows NE into the Ivanpah Valley Basin (USGS HUC 16060015; State GWB 6-30) or NW into the Shadow Valley Basin (part of USGS HUC 18090203, the Upper Kingston Valley, State GWB 6-22). *General elevation ranges in this basin:* Clark Mountain sits at 7,929 feet, while the lowest parts of these basins *inside the Preserve* drop to at about 3,500 feet.

- The Lower Mojave River Wash (GWB 6-40) cuts across the western tip of the Preserve, and merges with drainage from the Kelso Wash- Soda Lake Basin (State GWB 6-33). This typically dry drainage then slopes north, outside the Preserve, towards the Death Valley direction (Figure 2.2.), all part of USGS HUC 18090208, Mojave-Soda Lake Basin. *General elevation ranges in this basin:* The peaks in the area lie at about 2,000 feet, while the lowest part of the basin *inside the Preserve* drops to slightly under 1,000 feet.

2.3. SURFACE HYDROLOGY, RIVERS, AND ARROYOS

The Preserve's permanent streams are limited to short stretches of flowing water found below some of the large springs, such as Cornfield and Piute Springs. Storm runoff or snowmelt in the mountains can produce surface runoff or arroyo flooding for brief periods. The surface flow pours onto alluvial slopes or into washes, and is absorbed. Much precipitation also evaporates or is transpired (Thompson, 1929).

Localized surface runoff or summer flash flooding can be intense during storm periods, and some arroyos or washes present flood hazards. For example, several floods have taken place at the small community of Kelso, and a levee system is in place for protection (this topic is discussed in Section 4.4).

The Mojave River, west of the Preserve, is a typical desert river. Much of its water sinks into the porous alluvium, and the river is dry throughout much of its course for most of the time. The river originates about 100 miles west of the Preserve, in the San Bernardino Mountains, flowing through Victorville and Barstow, when it flows, ending at the Mojave River Wash, at the western edge of the Preserve. The Mojave River Wash, which barely cuts into the western tip of the Preserve, is normally dry.

Historically the Mojave River has produced some impressive floods upstream from the Preserve. The records (just above Victorville) show:

- Floods over 30,000 cfs in 1859, 1886, 1916, 1921, 1969, and 1978.
- Floods over 40,000 cfs in 1884, 1943, and 1965.
- Floods over 65,000 cfs in 1867, 1891, 1910, and 1938.
- An incredible flood of over 140,000 cfs, on January 22, 1862, is referred to as "the greatest flood of record" (San Bernardino County Flood Control District file).

In rare flood years, the Mojave River also has made it downstream to fill the Mojave River Wash, then flooded Soda and Silver Lakes (just off the NW edge of the Preserve). Impressive floods in 1938 and 1968 flooded the Silver Lake area, near Baker. Silver Lake was full for many months in 1938. The greatest flood on record in the area was in 1882 (Casebier, 1988, 1989).

Two major dams were completed upstream near Victorville in the 1970s, namely the Mojave Forks and Cedar Springs Dams, reducing the chances of massive flooding downstream in the Preserve's western edge. Growing and heavy urban and agricultural demands on the alluvial ground water of the upper Mojave River valley probably also reduces the chance that water can move as far downstream. About 71,000 acre feet per year on average are pumped to meet these demands (CDWR, 1993).

2.4. AN OVERVIEW OF THE HYDROGEOLOGY

This section describes the ground water in the greater Mojave area and in the Preserve, reviewing the ground-water recharge processes, directions of ground-water flows, and characteristics of aquifers.

The geologic formations in the Preserve generally fall into two main groups: the consolidated rocks of the mountains and hills, and the unconsolidated deposits in the valleys. The mountains consists of the older rocks, essentially impermeable igneous and metamorphic rocks of the pre-Tertiary age. These hard rocks of the mountain areas separate the ground water in one basin from another. Volcanic rocks of Tertiary age also appear, and have slightly more permeability, but still yield only a little water, generally of poor quality.

The valleys' unconsolidated deposits of Pleistocene age consist of gravel, sand, silt, and clay. These deposits are the principal ground-water reservoirs (CDWR, 1967a). (Note: ground water is defined as subsurface water in a zone of saturation, where water fills the pore spaces). Older fan deposits of Pleistocene age occur as isolated remnants which dip away from the mountains, which can store and yield ground water for wells (Dyer et al, 1963).

Mountain rains and snows recharge the upper levels of the ground-water aquifers (Thompson, 1929; Geoscience, 1995; Freiwald, 1984). The mountain springs and seeps appear along geologic fractures or fissures, and the springs' flows fluctuate greatly, depending on how much precipitation has occurred (Hall, 1981 and rancher interviews, 1998). The springs occur mostly along in the main mountain range, where precipitation is highest. Section 3.2 provides details on springs.

The main source of ground-water recharge is the runoff from the higher mountain ranges. Ground water is recharged when streams from the mountains --from storms or melting snow-- flow across permeable alluvial fans. The aquifers are then recharged by the water, which percolates through the alluvium. A significant amount of the water in the area of the Preserve is lost to evaporation and transpiration. This alluvium is referred to by some authors as the alluvial aquifer, and is an important ground water reservoir. In wetter years, surface runoff therefore plays an important role in the recharge of aquifers in the Preserve (Thompson, 1929; Geoscience, 1995; Freiwald, 1984). Many shallow wells are found along these alluvial areas.

Larger valleys, for example the greater Fenner and Lanfair Basins, below the Providence and New York Mountains, contain hundreds of vertical feet of sediment washed in over millions of years by runoff, and these unconsolidated materials constitute the deeper aquifers (CDWR, 1993). Few drillers' logs show the total thickness of these unconsolidated deposits; however, in places the deposits run deep. For example, the deposits in Lanfair Valley are over 500 feet thick, and in parts of Fenner Valley, about 10 miles south of the Preserve to Cadiz, over 1,100 feet (Freiwald, 1984). Information on the gradient of the ground-water is apparently limited to a few, scattered ground-water contours on the maps of Freiwald (1984). He shows a high mountain valley in the Providence Mountains (Gold Valley) with a 500 ft/mile drop in ground-water contours. A location near Fenner at the foothills of the Hackberry Mountains shows about 135 ft/mile gradient. A few map contours in the sloping reaches of the broader Fenner Valley, from Fenner to Cadiz (all outside the Preserve) shows a 16 to 36 ft/mile drop in the ground-water contour over a 20 mile reach.

The USGS has drilled over 2,000 feet in the Lanfair Basin (Freiwald, 1984), however, the water quality was very poor. Geoscience Inc (1995), which conducted the Cadiz study discussed in Section 4.2, believes the deposits to be perhaps a mile deep near Bristol Dry Lake, 12-15 miles south of the Preserve. Some deeper wells extract water from these valley areas.

Terminology for the aquifers varies. Some geologists refer to "upper and lower aquifers" or "younger and older aquifers" respectively --with a layer of less permeable materials separating the two (Moyle, 1972; Geoscience, 1995). The younger, upper aquifer is unconsolidated and highly permeable, supporting springs and shallow wells. The lower layer, of older Pleistocene age and sedimentary rocks of Tertiary age, store and yield water to deeper wells. Some geologists refer to a deeper "regional aquifer," over broader areas, composed of Pleistocene and Tertiary materials.

The "alluvial aquifer" near the Mojave River, consists of the relatively shallow deposits within about a mile of the river (Stamos and Predmore, 1992; Izbicki et al, 1995; Densmore and Londquist, 1997; Mendez and Christensen, 1997). Research has shown that considerable ground-water recharge occurs in the alluvium along the Mojave River. During years of big floods, the alluvium is recharged, yielding water to wells for months afterward (Buono and Lang, 1980; Hardt, 1969, 1971).

Recharge concepts are important from a viewpoint of ground-water management, in order to understand when water is sustainably used, versus being mined. Geochemical studies can help identify whether water comes from older geologic deposits or from more recently recharged aquifers. Isotopic studies of ground water in the Mojave River area, west of the Preserve, indicates that the alluvial aquifer has younger water, decades old or less. However, the deeper regional aquifer there contains some water recharged 20,000 years or more ago, when the climate was colder and wetter (Izbicki et al, 1995). The USGS notes that more research is needed to determine the age of the climatic periods that recharged the ground water found in some wells and springs (Gleason et al, 1992).

Deeper layers were recharged in wetter climatic periods, but it is not clear just how much recharge of the deeper aquifers in the Preserve occurs at this time --since research information is lacking. Also, in some areas spreading (artificial recharge) may not work well to recharge the deeper aquifers, when an impermeable stratum (e.g., caliche) sits above the deeper aquifer (Izbicki et al, 1995).

3. WATER SOURCES IN THE PRESERVE

3.1. INTRODUCTION

The water sources inside the Preserve include springs, seeps, wells, and guzzlers. Almost no permanent streams or reservoirs exist. A spring has a visible flow, whereas a seep normally is evidenced by riparian vegetation. Springs and seeps appear when ground water is forced to the surface by some geologic configuration, such as a hard stratum, fissure, or fault line. Typically, a spring's flow continues on the surface for a short distance, before disappearing back into the alluvial materials common to arroyos of the area. Springs and seeps offer essential water for wildlife. In most cases, spring water quality is adequate for wildlife and stock, and many springs yield potable water.

Many springs have been altered over the years by the installation of retention tanks, pipelines, and troughs for ranching use (Mojave NP, 1998). It is traditional to catch and store spring water in stock tanks during wetter periods of stronger flow, for use in drier times. Wells pumping water from greater depths typically are coupled with storage tanks, and windmills may provide the power.

Guzzlers are artificially constructed devices which catch surface runoff during storms and divert it to a storage tank, with a trough arrangement so that animals can drink from it.

Surface water is rare; however, in some igneous or hard rock areas, rainwater may collect as small pools in rock bowls (tinajas or "tanks") and remain for a few weeks, depending on the conditions of evaporation (Mendenhall, 1909). Wildlife benefit from these tinajas.

Playas in the area consist generally of clay with minor amounts of sand, and may include chemically deposited salts. Two playas, Soda Lake and Silver Lake, are some of the largest playas in the Mojave Desert region, having an area of about 60 square miles. These deposits were mostly laid down in temporary or perennial lakes in the playas during the Pleistocene epoch. Material continues to be deposited. In wet years, water may stand on the surface of a playa (Thompson, 1929).

Figure 3.1.a. Spring with tank for watering stock.

Figure 3.1.b. Water storage tanks at the Hole in the Wall area.

3.2. MAPS AND SURVEYS OF SPRINGS, SEEPS, AND GUZZLERS

Introduction and Overview

Over 200 springs and seeps have been identified in the Preserve. Mendenhall (1909) carried out some of the earliest surveys of springs in the Mojave, producing a book "Some Desert Watering Places," in 1909. He distinguished between local springs, fed by their immediate watershed, as opposed to "deep seated" springs, along fault lines. Thompson, in the 1920s, provided more information and prepared topographic maps showing the principal springs (Thompson, 1929).

As seen in Figure 3.2, springs in the Preserve cluster along the principal mountain chain of the Granite- Providence Mid-Hills -New York Mountains, with 78 percent of the springs and seeps in the Preserve falling between 4,000 and 6,000 feet elevation (Hall, 1981, BLM data, 1998). Most springs are small and flow less than 5 gallons per minute (Freiwald, 1984).

At the eastern edge of the Preserve, Piute Creek, fed by Piute Spring, flows for about a mile on the surface. The average flow of the spring during the past ten years has been about 42 gallons per minute (Mojave NP, 1998). Cornfield Spring also supports a small stream.

Table 3.2.a. Surveys, inventories, or summaries of the springs, seeps, wells, and guzzlers in the Mojave National Preserve area.

Activity	Description and Comments
Early 1900s reports	Mendenhall (1909) described "watering places" for horses in 1909. Later, Thompson (1929) did broad-overview field surveys to locate and generally describe springs in the 1920s and prepare maps.
USGS studies of the 70s - 80s	US Geological Survey geologists observed wells and springs in the 70s - 80s, measuring some water levels, with significant reports by Freiwald (1984) and Moyle (1972), who collected specific USGS data for the area. This report includes many of their observations.
USGS monitoring up until the 80s	USGS conducted ground-water monitoring of some 138 sites in the Preserve area from the early 1900s until the 80s (only 10 sites with many replications). Many of these data appear in this report.
Matthew Hall, early 80s	Hall reviewed existing maps of springs in the early 80s and prepared a summary paper. An overview of his paper is listed here, and a hard copy of his report is available at the Preserve.
Bureau of Land Management	During the 80s-early 90s, the BLM compiled a spring-seep-guzzler map, plus a list of the spring names, which is mostly included in a database file (a digital copy is on file at the Preserve).
The Society for the Preservation of Bighorn Sheep	The Sheep Society initially worked with the State et al from the 70s to develop a map plus description of guzzlers and springs in the Mojave Desert, and continue to update this material. Relevant excerpts appear in this report, with a digital file at the Preserve.
County of San Bernardino	The county maintains well permit records, with over 200 filings of well permits for the Preserve area, giving information on well depths, pump tests, locations, owners, etc. This material is described in this report.

Table 3.2.a (continued) California Dept of Fish and Game	The CDFC's guzzler crew operates over 100 guzzlers in the Preserve area (mostly small ones), in cooperation with the Sheep Society, BLM, et al, and has information on these sites.
California Dept of Water Resources	The CDWR's limited earlier well monitoring work is essentially included in the USGS database. CDWR water rights files in Sacramento has a list of 95 springs and 15 wells for the area (contrasted to over 200 well permits in the county office). The CDWR list appears in Appendix 2 of this report.
Ranching, and other private activities	Ranchers in the area are the principal holders of water rights and users of wells and springs (e.g., O-X Ranch with about 71 springs and 13 wells). Information is generally not recorded, and further interviews could reveal additional valuable details --for example, estimates of spring yields. The Town of Nipton has a well with water at about 500 ft depth.
Mining companies	Some mining companies monitor wells or springs, and some information is available in their reports (discussed in the section on mining issues in this report). Molycorp Inc located up to 27 monitoring wells for use in 1998 (Gsi/Water, 1998).
Southern Nevada Water Authority	The lower Ivanpah valley, just outside the Preserve, has ground-water monitoring by the SNWA. These data are summarized in this report, with a digital file of the data at the Preserve.

Hall's Summary

In the late 70s-early 80s, Hall (1981) assembled a broad overview map of springs for the Preserve. He used some 31 U.S. Geological Survey 15' quadrangle sheets, wildlife records from the Bureau of Land Management, and available literature to identify and list 230 springs and seeps. His master table describes the location of each spring, and gives some notes, for example, comments on a spring's estimated flow from a particular person's visit. Table 3.2.b. shows a typical example excerpted from Hall's master table. (The report is available in hard copy at the Preserve).

Table 3.2.b. Example of a typical entry in Hall's master table (Hall, 1981).

Master ID No. 86; BLM No. 71; USGS ID 11-6
Name: Burro Spring; 4440 ft elevation; T13N/R14E SE/SW of 14 Area: At base of NW Mid Hills, 5.2 km SE of Cima, 1.7 km SSE of Death Valley Mine Drainage: W, WSW to Kelso Wash Records: Possibly recorded, along with Live Oak Spring (11-20) as "the Troughs Spr" by Thompson, 1920. Flow: about 1960 = 9 gph; in 8/71 = 1 gph

The Bureau of Land Management's Surveys

The BLM compiled a map of springs, seeps, and guzzlers in the Mojave Desert, including the Preserve area. The map in Figure 3.2 summarizes BLM's California Desert Water Sources Database" or WHIP (Wildlife Habitat Improvement Project) map, showing springs in the Mojave NP. The map is drawn from the spreadsheet list of the springs/guzzlers, which gives coordinates, township/range details, latitudes/longitudes, and other numbers. Below is a small excerpt from this spreadsheet, to show its format. (The entire spreadsheet, about 15 hard copy pages, is in digital form at the Preserve).

Index			UTM E	UTM N	County	Sec	Twn	Rng	Merid	USGS Quad
376	G	11	060986	390839	SAN BERNARDINO	NESE10	14N	11E		GRANITE SPRING
997	S	11	067388	390818	SAN BERNARDINO				SBB&M	HART PEAK
1694	S	11	067405	390815	SAN BERNARDINO	SWSW07	14N	18E	SBB&M	HART PEAK
193	G	11	064978	390719	SAN BERNARDINO	NWSE14	14N	15E	SBB&M	IVANPAH
964	S	11	063336	390696	SAN BERNARDINO	NWSW18	14N	14E	SBB&M	CIMA DOME

(This is an excerpt of 10 of the 15 columns and 5 of the 468 rows in the WHIP database).

The Society for the Conservation of Bighorn Sheep (SCBS)

The SCBS probably has the most current list describing locations and conditions of big-game guzzlers in the greater Mojave Desert area, according to one wildlife biologist in the Mojave Desert area (personal communications, W. Yumiko, BLM Needles, 9/98). They also collect information on springs and wells. The Society's database for big-game guzzlers and springs draws on information from the State Department of Fish and Game (DFG), BLM, Fish and Wildlife Service, and others.

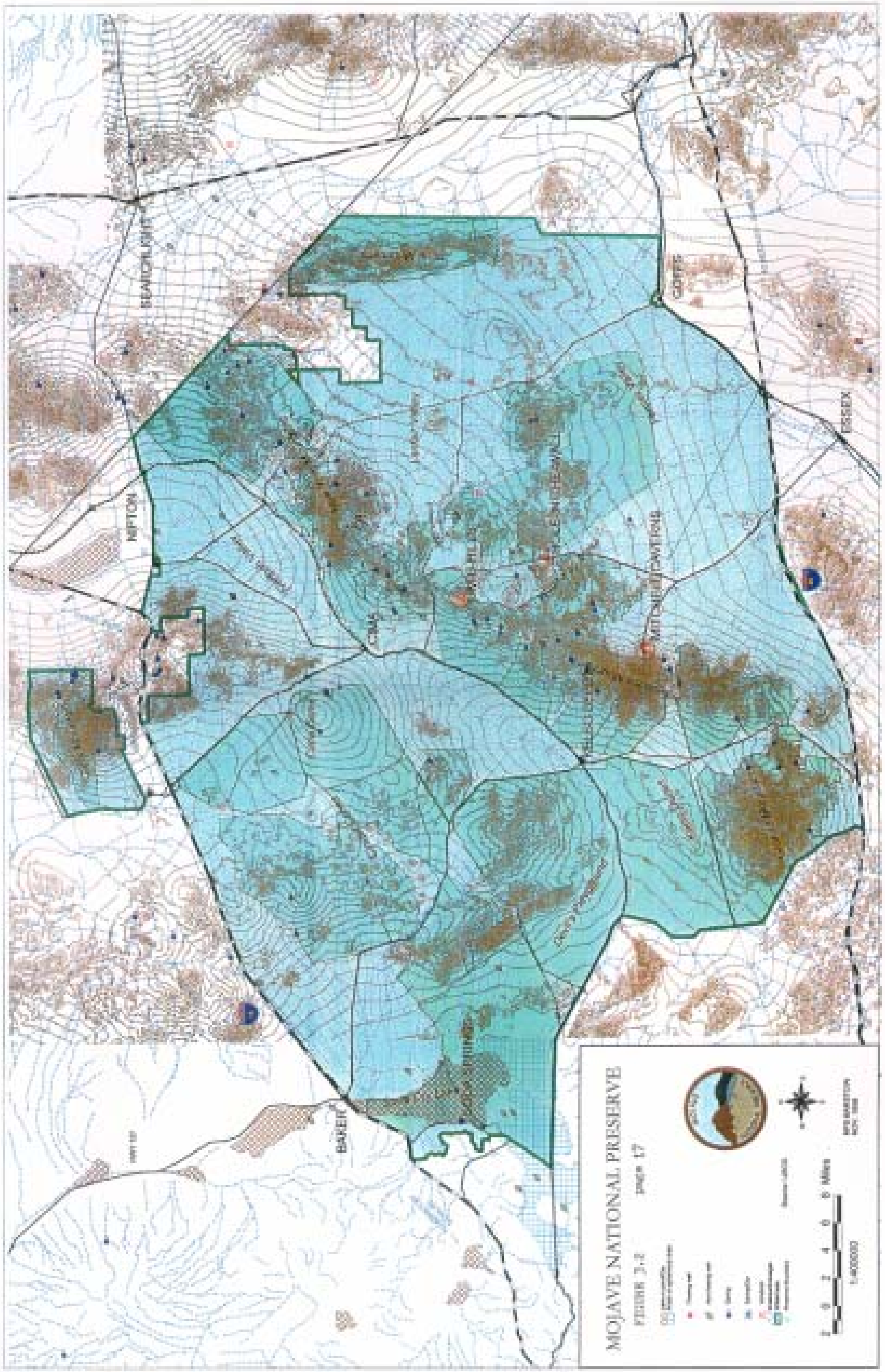
Robert S. Campbell in Las Vegas is coordinating, updating, and (as needed) correcting the SCBS database of springs and big-game guzzlers in 1998.

The Sheep Society's water packet dates back to records logged by the State Department of Fish and Game. Many individuals worked on the list in the 1960s-70s. The present computer edition contain over 1,000 descriptions of water sources, including:

- Read Me File: Describes how to use the files.
- EXCEL spreadsheet file with legal description and other data for each water source in the packet (over 1,000).
- Text files for each of the 34 areas defined in the spreadsheet, with WORD 7.0 detailed information about water sources (except big game guzzlers). For big game guzzlers, only a route description is included.

Data in the spreadsheet includes (among other notes):

- water name and identification.
- township/range/section/ ¼ section details.
- elevation and topographic map name/series details.
- UTM coordinates.
- name of area.
- water type (spring, tank, well, guzzler, etc).



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BAKER
ESSEX

Appendix 3 shows one of the nine files of the Sheep Society's database for the Mojave NP area, to illustrate the format and nature of the information. (Their other eight files for the Preserve area and a summary spreadsheet for the greater Mojave area are on file in the Preserve in digital format).

The US Geological Survey Information on Springs

Most of the USGS database on springs, their locations, and discharges comes from the 1970s-80s USGS work by Freiwald (1984) and Moyle (1972), plus earlier information by Thompson (1929). The USGS discharge data, with modifications, appears in Appendix 4. Appendix 4 is a compilation of the USGS database, plus other data inserted (by the author of this report) directly from the Freiwald and Moyle reports, which was not contained in the USGS database.

As seen in Appendix 4, the spring discharge data are old, incomplete, and not well replicated (with exception of Piute Spring, where monitoring is taking place).

Other Sources of Information

Valuable information on spring flows (mostly only estimates) could come from ranchers' practical observations over the decades (e.g., the Blair and Overson families). Further interviews with ranchers, miners, or other individuals are recommended, to record oral histories of spring use.

A Merging of Information

As discussed above, the information on springs and other water sources in the Mojave Desert area comes from an array of documents, maps, databases, history books, and articles, ranging from the 1800s up through ongoing efforts. The quality, accuracy, and completeness of these maps and databases are highly variable, and errors are transferred from map to map.

It would be valuable to analyze the array of reports, maps, and databases in conjunction with global positioning readings in the field, to build on the best existing information and to compile one credible map and descriptive set of water sources for the Preserve. This proposal is discussed further under technical assistance needs and in a Project Statement.

3.3 WELLS IN THE PRESERVE

Wells have played a vital role in the history of land use in the area. For example, the principal well at the O-X Ranch dates to 1912 (E&E, Inc, 1998). Some studies on wells have occurred, especially during the 70s and 80s. The most complete scientific work on ground water covering much of the Mojave NP area appears to be that of David Freiwald, hydrogeologist with the U.S. Geological Survey, who worked in California in the 1980s (Freiwald, 1984). His work on the Lanfair and Fenner Valley area covers the area of the Preserve most rich in wells and springs. The USGS database on water levels, water quality, and spring discharges includes many of his contributions. The USGS work by W.R.

Moyle in the early 70s provides equally valuable information on the Ivanpah Valley portion of the Preserve (Moyle, 1972).

Depths to water in wells range from less than 50 feet to over 500 feet (Figures 3.3.a and b), and a few wells go to over 600 feet deep. For example, the O-X Ranch well at 013N/016E/Sec7 was drilled to 879 feet, with the water table at about 350 feet below the surface. A few, rare wells have drilled to over 1,000 feet. However, as discussed below, most wells in the area are less than 100 feet deep (Freiwald, 1984).

Well yields are variable, but nearly all yield less than 100 gallons per minute. The US Geological Survey measured wells that yielded from 3 to 71 gpm in the Lanfair Valley area (sample of 10 wells), and 3 to 20 gpm in the eastern slopes of the Mid-Hills -New York Mountains area (sample of 5 wells). USGS measured wells in the Ivanpah Valley area, which yielded from 1 to about 600 gpm, but most wells were less than 50 gpm, as shown in Figure 3.3.a.

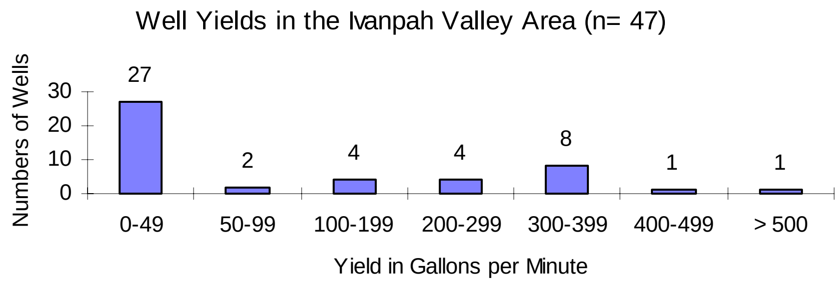

Figure 3.3.a.Well yields in the Ivanpah Valley.

State and Federal Monitoring

Up until the 1980s the U.S. Geological Survey and the State of California conducted routine ground-water level monitoring in the Mojave Desert area, taking water-level readings and sampling some water in wells of the area. But unfortunately this state and federal monitoring phased out in the mid-1980s. Consequently, *publicly-available* ground-water data for inside the Mojave NP boundary are sparse. Some more recent monitoring of ground-water occurs in conjunction with impact assessment of mining or other activities, but these data are limited in scope and area. Some of these impact-related observations are discussed in Section 4, on issues.

Contact by the authors with both the U.S. Geological Survey and the State Department of Water Resources in Southern California in 1998 revealed some 138 wells in the area of the Mojave NP, plus another 100 dry wells where monitoring had been attempted (communications and data loan, J. Huff, USGS, San Diego, 5/98). The USGS data comprises both federal and state (State Department of Water Resources) collections.

The 138 wells with water level readings appear in Appendix 1, showing that most well readings in the Preserve were only single observations. Most of the data are a decade or more old. Ten of the 138 wells had multiple replications and deserved a closer look, so the USGS then provided further details on these ten. This information is condense slightly and summarized in Table 3.3. The USGS also provided graphs on each of these 10 sites, showing Y-axis = depth to ground water and X-axis = calendar year.

In a nutshell, the data compiled in Table 3.3, for the 10 wells show:

- Depths (drilled) of the ten wells range from 14.5 to 1090 feet.
- Depths to water in the wells range from 14 to 418 feet.
- Depth to water is less than 100 feet in 7/10 of the wells.
- Basically random fluctuations are seen in the ground-water levels over the approximately 1950s-1980s period, i.e., no obvious patterns of decline or rise is seen from visual analysis of the 10 graphs. Presumably the random changes in levels relate to pumping and yearly climatic variations.

Hard copies of field notes for all the USGS well measurements are on file at the U.S. Geological Survey in their office in San Diego, with descriptions of exact locations of the wells.

A summary of the work by Freiwald, Moyle, and other USGS colleagues also provides an overview of the depths to ground water in the area, as indicated by readings of water level in wells. A synopsis of their data is presented in Figures 3.4.b and 3.4.c below. The charts provide an approximate picture only, since many of the wells being read were in use. Most of the points used in the charts were single readings on individual wells. As seen in the two figures, about three-quarters of the wells observed were less than 100 feet deep and many were less than 50. In the Lanfair/Fenner Basin, the water table was down to about 600 feet deep. In the Ivanpah Basin area, the USGS monitoring wells went down to about 400 feet (But note that Moyle also did at least one experimental well of over 2,000 feet deep in the Ivanpah area, as noted in Section 3.4. on water quality).

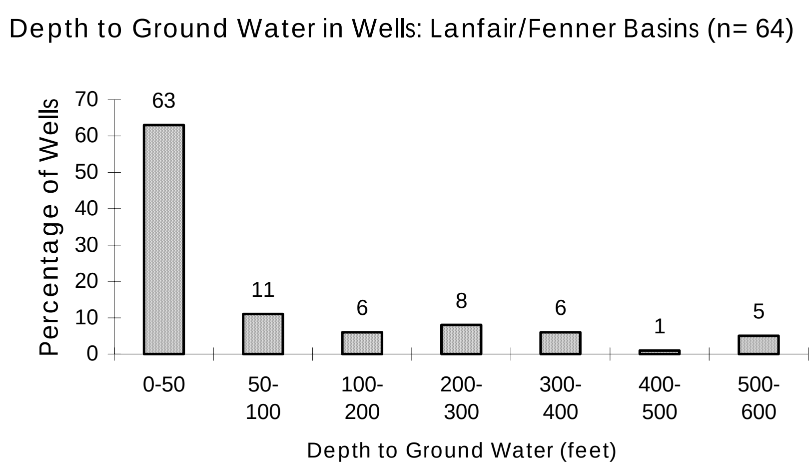

Figure 3.3.b. A synopsis of the field observations for the Lanfair and Fenner Drainage Basins by Freiwald (1984), showing the range of depths to ground water generally found around the basins, as indicated by his percentage of readings of wells in the field (single readings from individual wells, N = 64)).

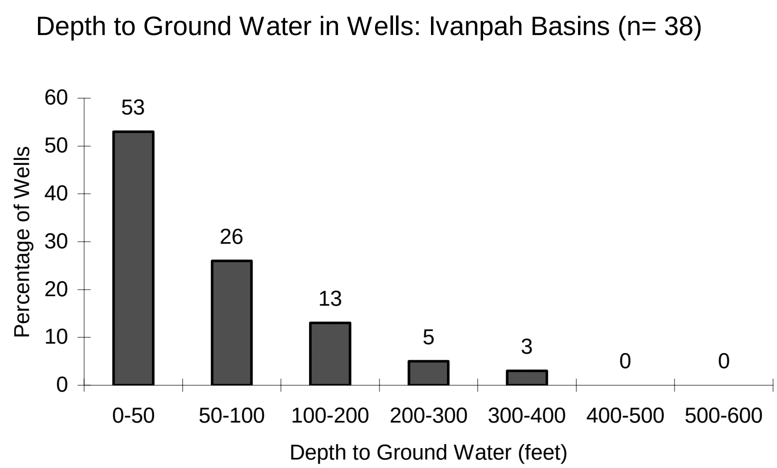

Figure 3.3.c. A synopsis of the field observations for the Ivanpah Drainage Basin by Moyle (1972), showing the range of depths to ground water generally found around the basins, as indicated by his readings of wells in the field (the points were mostly single readings from individual wells).

Table 3.3. Highlights of information on the ten monitored wells in the Mojave NP area having significant replicated readings.

```
LOCAL ID 008N017E02D001S                (Deep well at far SE edge the Preserve,
Fenner)
SITE ID 344931115103601
IN FENNER. DRILLED UNUSED WATER-TABLE WELL. DIAM 15.5 TO 12.5 IN, DEPTH 1090 FT,
15.5-IN CSG 0-121
FT, 12.5-IN CSG 0-582 FT. ALTITUDE OF LSD 2086 FT. RECORDS IN 1955-57 FURNISHED BY
DEPT OF
WATER RESOURCES. RECORDS AVAILABLE 1925, 1955-57, 1979 TO 1982.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM:
MEDIAN  387         HIGHEST  362.58  JUL 31, 1980         LOWEST  452.00  DEC 14,
1925

LOCAL ID 011N017E05R002S                 (Hackberry Mt area in SE  part of Preserve)
SITE ID 350328115094902
ABOUT 10 MI NORTH OF GOFFS. UNUSED WELL. DIAM 10 IN, DEPTH 98 FT. ALTITUDE OF LSD
3590 FT.
RECORDS AVAILABLE 1953-62, 1981.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 80         HIGHEST   63.70  JUN 07, 1962 LOWEST   93.10  MAY 14, 1957

 LOCAL ID 012N015E03L001S     (A shallow well in the Mid Hills area , Round Valley)
 SITE ID 350849115213001
 IN ROUND VALLEY. DUG STOCK WELL. PROBABLY DUG AROUND 1857. DIAM 5 FT, DEPTH 30 FT.
ALTITUDE
 OF LSD 5040 FT. RECORDS AVAILABLE 1917, 1953-60, 1981.
 WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
 MEDIAN  26       HIGHEST    8.86  AUG 29, 1981             LOWEST   30.70  MAY 24,
1956
```

Figure 3.3.c, continued

LOCAL ID 012N017E17J001S (Deep well in hills of Lanfair Valley area)
SITE ID 350705115094801
IN LANFAIR VALLEY. DRILLED STOCK WELL. DIAM 8 IN, DEPTH DRILLED 750 FT. ALTITUDE OF LSD
3910 FT. RECORDS AVAILABLE 1912, 1955-62, 1964, 1978.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 418 FT HIGHEST 400.00, 1912 LOWEST 431.20 MAY 07, 1964

LOCAL ID 013N008E01H001S (Shallow well in Soda Lake area)
SITE ID 351437116043601
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 24 FT HIGHEST 23.04 OCT 18, 1966 LOWEST 25.85 OCT 20, 1965

LOCAL ID 013N009E20J001S (Medium depth well about 5 miles southeast of Baker)
SITE ID 351148116022101
Drilled unused water-table well in alluvium of Pleistocene age. Diameter 16 inches, depth 400 feet. Altitude of land-surface datum 980 feet. Records available 1954-56, 1958-68, 1970, 1978-84.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 65 FT HIGHEST 64.69 JUN 30, 1978 LOWEST 66.57 MAR 14, 1962

LOCAL ID 014N016E22M001S (Shallow well in New York Mt area)
SITE ID 351644115150201
SOUTHEAST OF IVANPAH. DUG STOCK WELL. DIAM 3 FT, DEPTH 14.5 FT IN 1981. ALTITUDE OF LSD 4920
FT. RECORDS AVAILABLE 1953-60, 1962, 1964, 1981.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 14 FT HIGHEST 11.68 AUG 25, 1981 LOWEST 19.60 JUN 08, 1962 MAY 07, 1964

LOCAL ID 015N015E13G003S (Medium depth well in Ivanpah and Morning Star area)
SITE ID 352306115193903
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 368 FT HIGHEST 367.00 OCT 21, 1944 LOWEST 373.10 SEP 14, 1954

LOCAL ID 015N015E59N001S (Old medium depth well in Ivanpah Valley)
SITE ID 352713115204401
About 4.5 miles west of Nipton. Drilled unused water-table well. Diameter 18 inches, depth 125 feet with 12 foot tunnel at bottom in 1893, 110.5 feet in 1969. Altitude of land-surface datum 2630 feet. Records available 1916-17, 1953-56, 1958-60, 1965, 1969, 1979-84.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 99 FT HIGHEST 90.00 JAN 15, 1965 LOWEST 105.00 SEP 14, 1954

LOCAL ID 016N012E26N001S (Relatively shallow well at northern tip of Preserve, Shadow Valley area)
SITE ID 352626115402301
About 7.3 miles northeast of Paso Alto. Drilled stock water-table well. Diameter 48 inches, depth 64.7 feet.
Altitude of land-surface datum 3725 feet. Records provided by Department of Water Resources 1956-64. Records available 1956-64, 1969, 1978-84.
WATER LEVELS IN FEET BELOW LAND SURFACE DATUM
MEDIAN 45 FT HIGHEST 44.63 JUN 20, 1980 LOWEST 64.00 DEC 04, 1969

County Well Information

Valuable information on wells also is found in the *well permit* records at the County of San Bernardino, in San Bernardino. They supplied a list of those 213 filings[4] of those well permits falling into the townships which include some Preserve land. These records include information from when the 213 wells were installed, and includes:

- Name of the well owner;
- Year of well permit;
- Location of the well, by Township, Range, Section;
- Well type (individual, agriculture, test, monitoring, community, etc).

Ownership of the wells also is shown, and includes:

- Union Pacific Railroad;
- Several mining companies;
- Private ranches;
- U.S. Government, Interior;
- Universities;
- Development companies;
- Energy companies (Chevron, Arco, etc);
- Individuals;
- A town.

Each item (permit) on the list of 213 can be matched to the detailed hard-copy files in the San Bernardino County office. These hard copies include:

- Details on the well's depth and its physical characteristics;
- Precise location of the well, with a map;
- Names, addresses, other details on the owner;
- Estimate of water yields from the driller's pump test;
- Driller's log, showing materials encountered by depth.

Through a study of these records, it would be possible to better understand depths of wells and their yields in the area.

Nevada and Other Information

The Southern Nevada Water Authority monitors ground-water levels in the lower Ivanpah Valley, just over the state line. At times in the past they also have monitored water levels in the Nipton area (personal communications, SNWA, August, 1998). Their observations are discussed in Section 4.2 on issues in the Ivanpah area.

The work by Gsi/Water to develop monitoring for Molycorp Inc provides other examples of depth to the water table (Gsi/Water, 1998). They note that the small community of Nipton has wells with water at 368 and 491 feet. The Primm Valley Golf Club well has water at about 150 feet deep. A well about 3 miles NW of Molycorp Inc's main evaporation pond has a depth to water of 145-165 feet. The consulting work by ENSR Engineering (1996) gives other examples, noting that Molycorp's main wells in the

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[4] A hard copy of the summary list on file at the Preserve. The master files with complete records are at the County of San Bernardino offices.

Ivanpah and Shadow Valleys are drilled from 700-1000 deep, but refer to water table in the Ivanpah Valley as mostly at around 200 feet. Other well examples appear in Section 4.2.

3.4. WATER QUALITY

Much of the information on water quality for the Preserve's springs and wells comes from the field surveys and studies of the U.S. Geological Survey in the 1970s-80s or before. The USGS provided a copy of their water quality database for the Preserve area, which includes 74 wells and springs (i.e., in hard copy format about 79 pages of font number 8 material). The 74 data sets are on file in digital format at the Preserve.

Water quality in the area is exceptionally varied, ranging from potable to highly mineralized, or high in sodium or nitrates. This variation is presumably a result of the area's geology. Appendix 5 shows 8 representative examples drawn from the data set of 74, to illustrate some of the characteristics of water quality. An general analysis of the data set of 74 shows the following broad patterns:

- The waters of mountain springs and shallow wells in the area often have acceptable quality for livestock or wildlife use, and in many cases are potable --in agreement with the interviewed ranchers' opinion that the water quality is mostly good or very good. However, waters are typically hard to very hard on viewing the USGS data and marginal to high in sodium (Examples 2, 3, and 7 of Appendix 5 illustrate this group).

- Many deeper wells at relatively lower elevations, for example in the Lanfair Valley area, also yield acceptable, albeit hard water (Example 4 of Appendix 5 illustrates this group).

- Waters of larger springs found at relatively lower elevation can be hard, and certain constituents, such as nitrate, may be above the recommended potable criteria at times (e.g., for nitrate 10 mg/L is the upper limit). Example 1 shows this type.

- In contrast to the good water of most mountain wells, occasional mountain wells may contain excessive salts, sulfate, and hardness –related to the complexity of the area's geology (Example 6 shows such an exceptional well).

- As would be expected, water pumped from playa area wells can be exceedingly saline (Example 5 in the Appendix illustrates this situation).

- An experimental well drilled to over 2,000 feet revealed that hot, highly mineralized water can be encountered at greater depths (Example 8). USGS geologist W.R. Moyle in 1969-70 drilled up to 2,600 at one site, and the water was "steaming, 163 degrees F, salty and sulfurous . So apparently the water found at great depths will not necessarily have acceptable quality.

Table 3.4. Highlights of the 8 examples of well water quality presented in Appendix 5.

Example Number	What the Example Represents
Number 1 (Site 22)	Example of a larger spring with marginal water quality (nitrate levels a bit high) at 3,550 ft elevation (Vontrigger Spring)
Number 2 (Site 28)	Example of a 30 ft, shallow well with hard livestock water, sodium high, at 5,040 ft elevation (high in Mid Hills)
Example 3 (Site 34)	Example of a 30 ft, shallow well somewhat salty, moderately hard water at 4,610 ft elevation (Hackberry area)
Example 4 (Site 37)	Example of a 700 ft, deep well with marginal hard water (nitrates and sodium a little elevated) at 3,980 ft elevation (Lanfair Valley area)
Example 5 (Site 40)	Example of a well with unsafe salt levels (Na and Cl) (Soda Lake area)
Example 6 (Site 58)	Example of a 14.5 ft, shallow well with very hard, saline water and excessive sulfate at 4,920 ft elevation (in the New York Mts)
Example 7 (Site 21)	Example of a larger spring with acceptable sodium, moderately hard water at 4,440 ft elevation (Hackberry Spring)
Example 8 (Site 67)	USGS experimental well down to 2,240 feet, showing “steaming salt slurry” at that level (in Lanfair area)

The examples indicate the importance of water analysis of ground water intended for consumption, to include analysis of metals, sodium, nitrate, and radioactivity. The available water quality data sets are dated and include only a few replications. No agency conducts routine monitoring in the Preserve area at this time. Therefore, this report recommends that a simple monitoring program for the Preserve would be desirable, to provide baseline information essential for any future evaluations of impacts on water quantity and quality. Monitoring of mining is important as well; therefore, one of this report’s proposals (Project Statements) focuses on mining impact monitoring.

3.5. GUZZLERS IN THE PRESERVE

A guzzler is a low-maintenance, self-filling device that catches and stores storm runoff, to provide water for hunted wildlife in arid areas. Non-game wildlife such as reptiles, songbirds, insects, cattle, and feral burros also use these manufactured devices. Birds enter the covered tank through an opening and walk down a ramp to the water. For bighorn sheep, piping extends from the storage tank to a drinking trough equipped with a float valve, which regulates the flow.

There are more than 100 artificial water impoundments in the preserve including livestock tanks and troughs, six big game and 133 game bird guzzlers (Figure 3.5). The California Department of Fish and Game, the Bureau of Land Management, and volunteers developed the guzzlers before the area was designated a National Preserve in 1994. Six big game guzzlers were constructed for bighorn sheep use.

All six of the bighorn guzzlers fall within wilderness areas. These guzzlers are located on the north slope of Clark Mountain, the northern, central and southern parts of Old Dad Mountain, Kelso Mountain, and in the Northern portion of the Piute Range. The game bird guzzlers are located throughout the preserve.

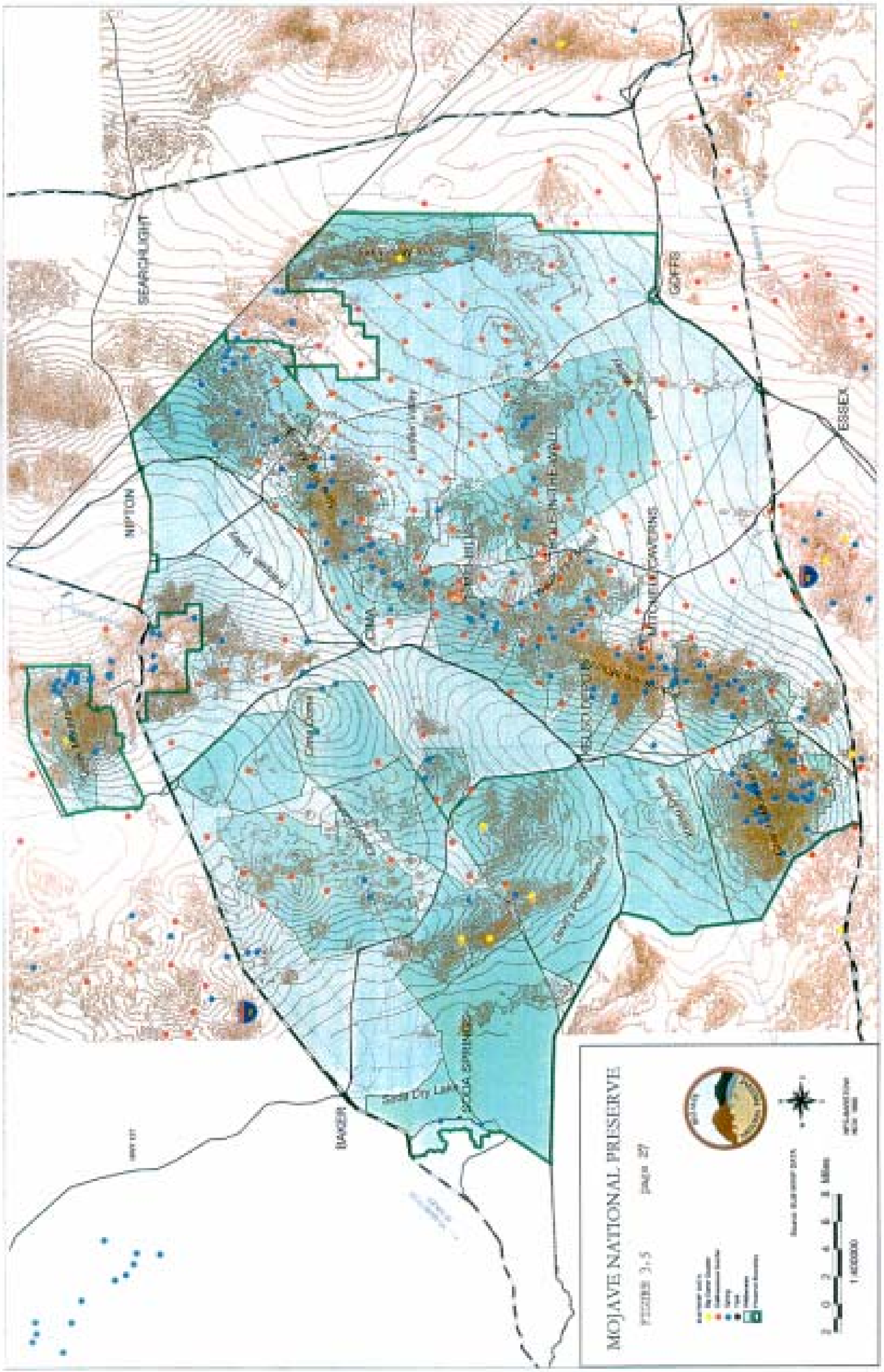
Excess numbers of game can damage food and cover in areas near water, and in arid lands this damage is long-lasting. Damage of this type appears in the Mojave Desert around big game guzzlers, but not around guzzlers designed for game bird use (McGill, BLM, personal communication, Preserve staff).

A disadvantage of guzzlers is that dead tortoises are sometimes found in them and the believed cause of death is drowning (Frank Hoover, personal communication, Preserve staff). In an examination of guzzlers on BLM lands, one in four were found to contain large dead mammals, and one in five were found to contain dead tortoises The BLM further observed that all guzzlers with dead animals in them were constructed of fiberglass, and no animal carcasses appeared in concrete guzzlers (McGill, BLM, personal communication, Preserve staff).

The U.S. Fish and Wildlife Service recommends that "If guzzlers are constructed, they should include fencing or other means to exclude tortoises" and that existing guzzlers should be retrofitted with exclusion devices (Mojave NP communications with FWS, 1996). Fiberglass guzzlers should contain escape ramps, to avoid trapping.

Diseases also are sometimes associated with guzzlers. For example, bighorn sheep die-off occurred when the sheep contracted Botulism Type C in guzzlers in the Old Dad Mountain area in 1996 (Swift, 1996).

The issue of how to manage artificial water developments for wildlife is discussed in Section 4.6.


MOJAVE NATIONAL PRESERVE
FIGURE 3-5
page 27
NIPTON
SEARCHLIGHT
GOFFS
ESSEX
CIMA
HOLE-IN-THE-WALL
MITCHELL CAVERNS
SODA SPRINGS
Soda Dry Lake
BAKER

3.6 WATER SUPPLY IN THE PRESERVE

This section provides an overview of the public water supplies maintained by the NPS in the Preserve's campgrounds and other sites. As in all National Park Service areas, the Public Health Service evaluates the public, potable water supplies on a regular basis, to flag any problems and advise on any improvements needed to maintain acceptable water supplies.

Mid Hills Water System

Two wells provide water at Mid Hills. One well, across from the entrance to the campground, is powered by a windmill, so its yield depends on the windmill's speed. The yield is about 1.5 – 2 gallons per minute (gpm). The depth to water is approximately 90 feet; however, the well not been monitored for water table levels. An 8-inch diameter casing is used. Two 2750 gallon water tanks are located above the campground. Chlorine is injected. The campground's water system was just reconstructed, including new water line mains made of 1-1/2 inch diameter PVC pipes, and in 1998 some further repairs are underway.

The Mid Hills second well is about 150 yards south of the first well. This well also has not been tested or monitored for yield. The water is 150-200 feet in depth. A 12-inch diameter casing is used.

Additional information would be valuable, to evaluate the fluctuation of the water table, drawdown, and recovery rates of these wells, in order to determine sustainable yields.

Soda Springs Water System

The NPS owns the well in use at Soda Springs; however, the Cal State Consortium (of state universities) manages the water system, and is currently applying for proper water permits with San Bernadino County to operate the system. A cooperative agreement will be signed in the future which will determine exact details on the management of this system. (Further information on the system and the status of permits can be requested from manager Rob Fulton (760) 733-4266 at the site).

Authorized use of park water will be perfected in the name of the National Park Service, since NPS policy states "All rights to the use of water diverted or used on federal lands within the national park system by the United States or its concessionaires, lessors, or permittees will be perfected in the name of the United States" (U.S. Department of the Interior, 1988). Therefore, the NPS holds the right to use ground water from the well at Soda Springs. Any permit and cooperative agreement affecting the use of water from this well should recognize the NPS as the owner of the well and water right. The Preserve should contact the NPS Water Rights Branch to determine what course of action should be taken in regard to this issue.

The existing well is located near the west pond at Soda Springs. The raw water quality of this well is poor, and recent water sampling has identified a high level of radioactivity, apparently from a naturally occurring source. Depth to water table is not known but is most likely less than 50 feet from the surface. BLM had proposed an additional well further south near an abandoned goat farm, to reduce drawdown on the existing well, so this option for a new well still needs evaluation.

The Cal State resident staff attain potable water through a reverse osmosis treatment system, and tests show that the system effectively brings the water up to acceptable levels for a public use. Chlorinating is by inline injection. The NPS only uses a small portion of the water for a public comfort station to flush toilets, not for potable needs.

Improvements obviously are needed in the system, and a technical evaluation of the existing system and assessment of the potential for new wells should be a first step. Old BLM records need checking, to determine if any additional details or earlier evaluations have been filed from decades past. The NPS would need to discuss these concerns with the Cal State Consortium, to agree on cooperation and responsibility to accomplish these assessments, designs, and eventual improvements.

Hole in the Wall Campground

The existing water supply system is inadequate to serve the campground/equestrian area, the fire station, and a local rancher's needs. The system includes three temporary 4,000 gallon storage tanks, in three separate sub-systems attached to the well. The well, which dates from the early 70s, is about 1500 feet north of the fire station, has a depth of 593 feet, with a water level at about 493 feet. The casing is perforated with vertical slots from the 376 foot depth down to the bottom. Apparently iron bacteria encrustation is occurring in the lower 10 feet. Pump testing showed the well to be a "very low producing well," inadequate for public use, with a production of only about 3,600 gallons per day. The water quality is hard but acceptable.

Since the system is poor, in 1998, NPS's Denver Service Center (DSC) developed a design to upgrade the distribution system, storage tanks, piping, and disinfection mechanism, and to install automatic controls. However, the DSC plan does not provide for a new well --which obviously is still needed (NPS, 1998).

Follow-up technical advice and assistance on design is needed before a system upgrade can occur.

Kelso Depot

There are no firm plans at this time for an eventual water system at the historic Kelso Depot, which is to be restored for use as a visitor contact point, for ranger offices, or other NPS roles. A report on Kelso Depot as a historic structure (Mojave NP files) identified two options for water which the NPS could follow. Option 1: Drill two wells and install the necessary water treatment equipment to serve the depot. Option 2: Develop a long-term cooperative agreement with the Union Pacific Railroad Company (UP) to allow the NPS to use water from a UP water system.

Cornfield Spring, a few miles above Kelso in the mountains, was flowing over moss-covered rocks at an estimated 225 gallons per minute on 9/23/98 (personal observations by the author). The stream flows for perhaps a quarter mile before disappearing in the alluvium of the arroyo. Flows of 250 gpm at Cornfield Spring are common, according to rancher C. Overson (personal communications, 9/98). At one time this spring presumably served as water supply for locomotives or for Kelso, given the remnants of old pipes coming down from the spring to an old storage reservoir above the town of Kelso.

As identified in discussions with the Bureau of Land Management (personal communications, BLM, Needles, 9-24-98), the immediate Kelso area's soils no doubt contain organic solvents, fuels, creosote, and other contaminants or hazardous materials resulting from the decades of heavy railroad activity in the immediate vicinity. Therefore, any development of a new well in the area, or cooperation in a UP system, should include evaluation of the potential for contamination or evaluation of any existing well's water quality.

4. ISSUES OR POTENTIAL ISSUES RELATED TO WATER RESOURCES

4.1. MINING ISSUES RELATED TO WATER RESOURCES

Introduction

Historically, mining has been a major land use in the Mojave Desert. Mineral resources within the Preserve include gold, silver, iron, cinders, limestone, and industrial rare earths (lanthanide elements), and a number of these minerals have been extracted commercially (Mojave NP, 1998).

Two larger mines, the Molycorp Inc operation at Mountain Pass, and the Viceroy Gold Corporation's mines at Castle Mountain, are dominant in the area (Figures 4.1.a and 4.1.b). These major mining areas and some other nearby mines were excluded from the Preserve when drawing the boundary. Some smaller operations, such as the Morning Star Mine, lie within the Preserve boundary. Recently closed mines, such as the Colosseum Mines in the Preserve's Clark Mountain area, still have the potential to affect ground water and other aspects of the environment, so the concern with closed mines is mainly for rehabilitation of the land and longer-term monitoring. Some long inactive mines, for example the Vulcan Mine worked in the 1940s, left large open pits and other scars behind, and restoration of the landscape could be a long-term objective of the Preserve for some of the older mines.

Both active and closed mining operations in and near the Preserve have the potential to harm the water resource and other aspects of the environment. Once pollution from mining enters an aquifer, the contamination can persist for decades or centuries, and can extend down valley over many miles (for example, mining from the 1800s still contaminates streams over great distances in some areas in the Appalachian and Rocky Mountains).

In simplest terms, water resource impacts from mining in the Preserve area can cause:

- ground-water table drawdown;
- erosion and sedimentation problems on hillslopes and in arroyos; and
- ground-water contamination.

Eventually these impacts can reduce the flow of springs, contaminate potable wells and springs, lower ground-water tables in wells, and eventually pollute deeper aquifers, with pollution plumes extending for many miles. The Preserve managers are logically concerned about the potential effects of the mining.

The following sections provide a brief overview of mining activities and discuss some of the related monitoring and water resource assessments now underway.

Molycorp Inc Activities -- Background

The Molycorp mine activities continue to be the Preserve's most evident environmental concern. Molycorp Inc, a subsidiary of Union Oil Company of California, has a major rare earths mining operation at Mountain Pass, California, at I-15 adjacent to the Mojave National Preserve's northern boundary (among other claims in the area). Its mining activities occur in the mountains near the northeastern point of the Preserve, with waste disposal extending into the Ivanpah Valley area (Figure 4.1.a). Molycorp started mining in the Mountain Pass area in 1951, continuing to the present. The mine employs about 300 workers.

Open pit mining methods are used to extract lanthanides (bastnasite ore) at the Mountain Pass mine, with about 2,000 tons of ore being mined daily. It is hauled to a crushing plant, and a flotation process yields bastnasite. Solvent extraction is used to produce the various lanthanide elements, which are up to 99.999% pure (Ririe and Nason, 1991). Over 90 percent of each ore ton is rejected in a slurry to a tailings pond. The mining expansion planned includes increase in capacity of tailings ponds. An evaporation pond of about 115 acres, filled via a pipeline, is located in Ivanpah Dry Lake bed (ENSR, 1996).

The ore processing produces or uses many hazardous substances, including organic solvents, fuels, acids, flocculants, ammonia, chlorine, nitrate compounds, and metals. The Mountain Pass bastnasite ore also contains small concentrations of naturally-occurring radioactive materials, mainly uranium-238 and thorium-232 (ENSR, 1996).

Water supply for the mining operation is piped in from well fields in the Ivanpah and Shadow Valleys (Figure 4.1.a), providing about 600 gpm for the operation. Details on the wells appear in the report by ENSR (1996), on the Molycorp Mine.

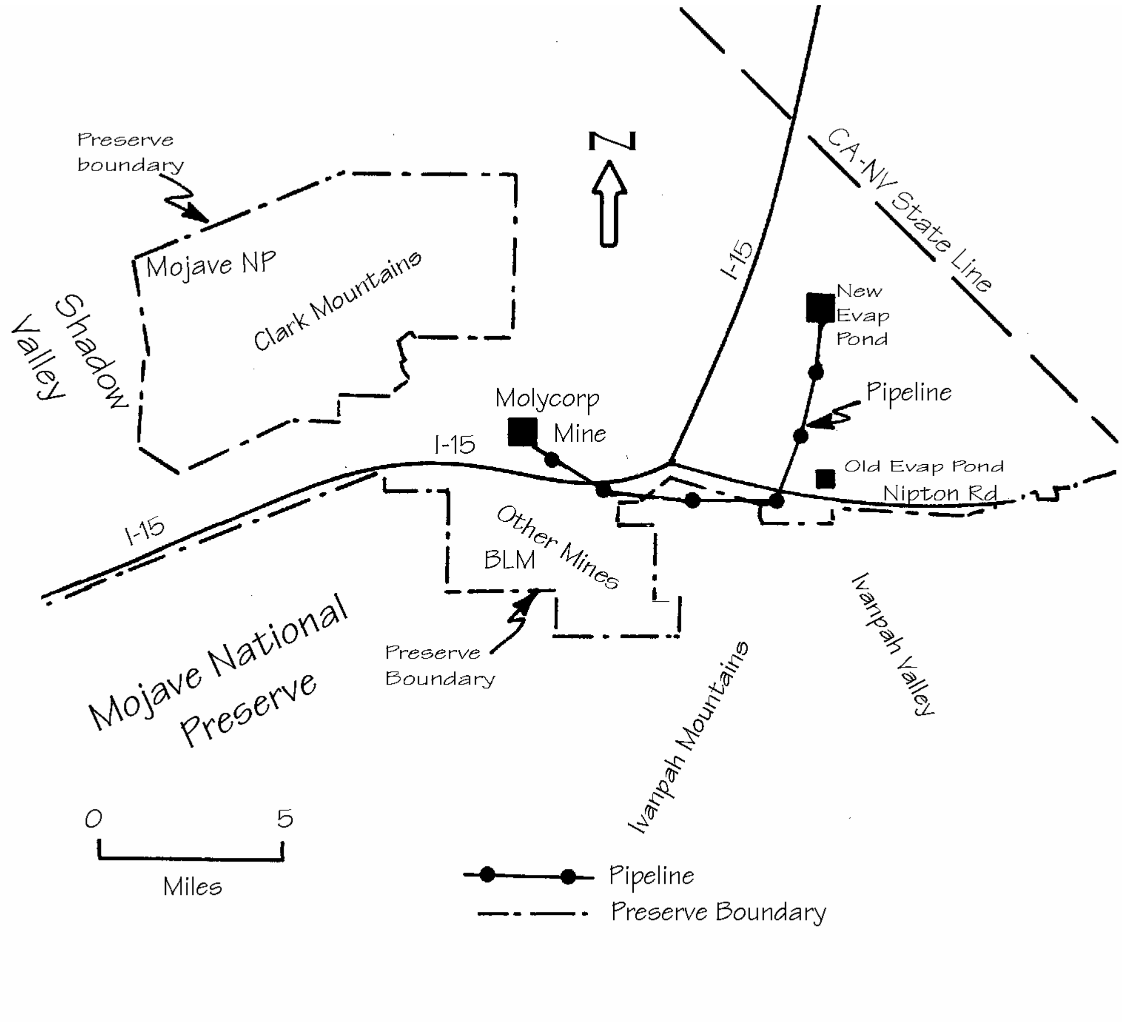


Figure 4.1.a A sketch of the Molycorp Inc operations at Mountain Pass, showing the pipeline, principal evaporation pond (new pond), and other features in relation to the Mojave National Preserve boundary (Note, Molycorp has various claims in the general area, which this sketch makes no attempt to show).

Molycorp Inc Spills, Contamination, and Water Level Impacts

Pollution from the mining is a concern, and several aspects of the mining operation handle or store pollutants, including:

- The mining area, and the associated tailings pond (containing tailings as old as 1968).
- Storage ponds (mining products are stored in three lined ponds).
- Overburden stockpiles and crushed ore pads (near the mine and floatation plant).
- The Ivanpah Playa evaporation ponds(principal one about 115 acres in size).
- The 14-mile pipeline, from the mine to the Ivanpah Valley evaporation pond.

The hazards in the Mountain Pass area are reportedly serious enough that some mine staff housing has relocated. Nonetheless, a state Environmental Impact Report apparently has not been finalized, and no U.S. Environmental Protection Agency "ranking score" for Superfund Sites has been done. Public involvement is needed as well. The state plays a key role in these issues; whereas, EPA has not been a big player.

The 14-mile pipeline runs east from Molycorp's rare earth mining/processing plant at Mountain Pass, CA for about 8 miles, and about a mile south, then north for about 5 miles to the 115-acre evaporation pond in the Ivanpah Dry Lake Bed, near the California-Nevada state line, The pipeline runs through the northern corner of Mojave NP and part of the BLM Needles Resource Area (Figure 4.1.a).

The pipeline has leaked or burst on many occasions. For example, in July-August, 1996 an estimated 230,000 gallons of pipe scale and waste effluents were released at nine or ten separate locations along the pipeline, during a cleaning operation. The spill contained radioactive radium, thorium, and uranium, as well as lead and arsenic, at above the regulatory level of concern. Some of the spill occurred on Preserve land (Figure 4.1.a shows where the pipe crosses a corner of the Preserve). A cleanup was organized involving state, federal, and county agencies, and the eventual cleanup cost could be $7 million (Mojave NP, 1998; Molycorp, 1996d).

During the 15 years from 1984 through 1998, over 50 recorded pipeline breaks and spills have occurred (in every year but 1986). The more significant spills have included:

- 1989, a 45,000 gallon wastewater spill near Ivanpah-Nipton Road intersection;
- 1992, a 403,500 gallon wastewater spill near Ivanpah-Nipton Road intersection;
- 1995, a 93,000 gallon wastewater spill near Ivanpah road;
- 1996, about 230,000 gallons at various points along the pipeline; and
- 1998, reportedly many small spills from the pipe (Molycorp,1996d, and personal communications, BLM, Needles, 1998).

Molycorp Inc has prepared an illustrated and annotated 1998 map depicting the exact location and volumes of the 40 spills occurring from 1984 to as of April 1998 --not including many smaller spills which reportedly have occurred during 1998 since the map's completion (Molycorp,1996d). Also, Molycorp Inc reportedly has recently completed a multi-spectral analysis for the pipeline spill issue, using imagery at 1:24,000 to illustrate the concentrations of contaminants at spill points (communications, BLM, 9/98).

The impact of mining on ground-water levels is a concern. Ground-water tables in the vicinity of the Molycorp Ivanpah Valley well field have declined an average of 2 feet per year since pumping began in the early 1950s, which represents a total water level decline approaching 100 feet. Aquifer recharge is apparently less than withdrawals. The combined Ivanpah-Shadow Valleys water supply wells produce about 600 gpd (ENSR, 1996).

Dewatering of old mining pits is another question to consider. What are the effects of the dewatering itself, as well as the possible impacts of the water disposed of on springs in the area? (personal communications, H. Davies, Dept of Int, 11/98).

The mining company is developing additional monitoring to observe evaporation ponds for leaks (the main Ivanpah Playa ponds have been used since 1987, the older ponds even longer). In 1998, the firm Gsi/water of Pasadena has advised Molycorp on ground-water monitoring, reviewed over 400 wells in a 20 mile radius of Nipton, and identified 11 wells for a ground-water monitoring program for the general Ivanpah valley area. These wells are described in the reference by Gsi/Water (Gsi/Water, 1998). They essentially will sample for common inorganic cations and anions, plus radionuclides, water yield, and water depth.

Quarterly ground-water sampling now provides information on the evaporation pond area, with data from Molycorp as well as an independent laboratory (Dynamac Corp, July, 1998). Six wells sampled were from the evaporation pond area, Ivanpah Valley. Comparisons also were made with a few U.S. Geological Survey samples from the area in 1997. Certain chemical constituents in some samples exceeded water quality standards: in chloride, sulfate, gross alpha, Ra-226, and total uranium (however, could not tell if the high values were caused by the evaporation ponds, or natural, given the limited data).

In 1998, work also is underway for Molycorp by the companies Geomega and TRC to provide models and data in response to the state cleanup and abatement process, related to spills in the area, and in relation to state environmental assessments. Geomega will use computer modeling to simulate water quality. The TRC work proposes a model to predict future impacts on water resources by the evaporation ponds and to predict migration of pollutants in the Ivanpah Basin (Molycorp, 1998b).

Molycorp Inc 1998 Proposal for Mining Operation Expansion

Expansion of the mine site is proposed, to:

- enlarge the surface area and depth of the main pit;
- expand existing overburden stockpiles;
- enlarge the existing North Tailings Pond through the year 2000, before constructing a new tailings storage impoundment (East Tailings Pond); and
- construct a new borrow pit for material for the new East Tailings Pond dam.

The expansion will occur over a 30-year period, plus 5 years of monitoring afterward (ENSR, 1996). The NPS is naturally concerned over this major expansion of the mine and its waste disposal facilities.

A draft environmental impact report/environmental impact statement (EIR/EIS) for a proposed mining operation expansion has been prepared for the County of San Bernardino, and reviewed by the Mojave NP staff (ENSR, 1996). The Superintendent of Mojave NP and NPS's Pacific Great Basin area Supervisor expressed concern to the County of San Bernardino over the planned expansion and potential impacts of hazardous wastes and ground-water drawdown on the water resources in the area (Mojave NP correspondence). Reportedly a new EIR/EIS will be prepared. The Mojave National Preserve natural resource staff will need to continue close cooperation with the state's Regional Water Quality Control Board on the expansion proposal, and play an active role in the environmental review process.

Castle Mountain Mining Project, Viceroy Gold Mine

Viceroy Gold Corporation is the operator of Castle Mountain Mine, which is located on BLM land adjacent to the Preserve's eastern boundary, and flanked on three sides by the Preserve (Figure 4.1.b). The operations are reportedly modern, and incorporate recycling and newer techniques (compared to economically marginal operations such as Morning Star). Therefore, the BLM (personal communications) and others regard Viceroy as a more responsible operation in terms of efforts to protect water quality. The aesthetic impacts of the tailings are striking, but these piles do not necessarily influence water, if erosion is controlled.

A special concern over the Viceroy operation is the potential effect of the mining on the quality or quantity of the flow at Piute Spring, which also supports a short, permanently flowing stream. Piute Spring lies about 11 miles SE and downslope *and also hydraulically downgradient* from the mining area, at the lower end of the Lanfair Valley Basin, shown in Figure 2.2 or the lower end of the Piute Range, and shown with the arrow on Figure 4.1.b. It is probable that the primary source of water for Piute Spring flow is from ground water in the Lanfair Valley alluvium, flowing through the volcanic rocks which form the mountains of the Piute Range (ES Inc, 1989).

Concern over the possible overall depletion of the broader, Lanfair Valley ground-water resource also rises. Based on its calculations of precipitation, recharge, water use, and spring flow, and the testing of models, the Viceroy company does not believe that the approximately 725 acre feet per year it uses will lower the valley water table or Piute Spring flows (calculations described in ES Inc (1989) and the model in Broadbent 1997), and discussed in the 1997 EIS (BLM, 1997). One model (Broadbent, 1997) shows 794 acre-feet per year of water use is feasible.

A baseline data collection program is in place, which is a system of wells in the Lanfair Valley, to act as a warning system (BLM, 1997). Monitoring of the flow and water quality of Piute Spring Creek is conducted jointly by Viceroy Gold Corporation and their contractor, Broadbent and Associates (Las Vegas area).

Viceroy's contractor produces periodic reports on water levels and quality for Piute Spring and monitoring wells (Broadbent, 1997), giving: Piute Spring flows (monthly), depths to water in wells, and a basic suite of inorganic water chemistry analyses. The monitoring has occurred since 1987 (BLM, 1997), but the operator has proposed to reduce the frequency of monitoring the wells from monthly to only twice yearly. Will this be adequate? It would be good to statistically review the arguments for twice-yearly measurements to answer this question.

The company prepares various environmental reports, including: a Toxic Release Inventory (new requirement for mines in 1998); an Annual Report (Feb., 1999); a Mitigating Monitoring Compliance Report for the County and BLM, annually; and an Annual Revegetation Report.

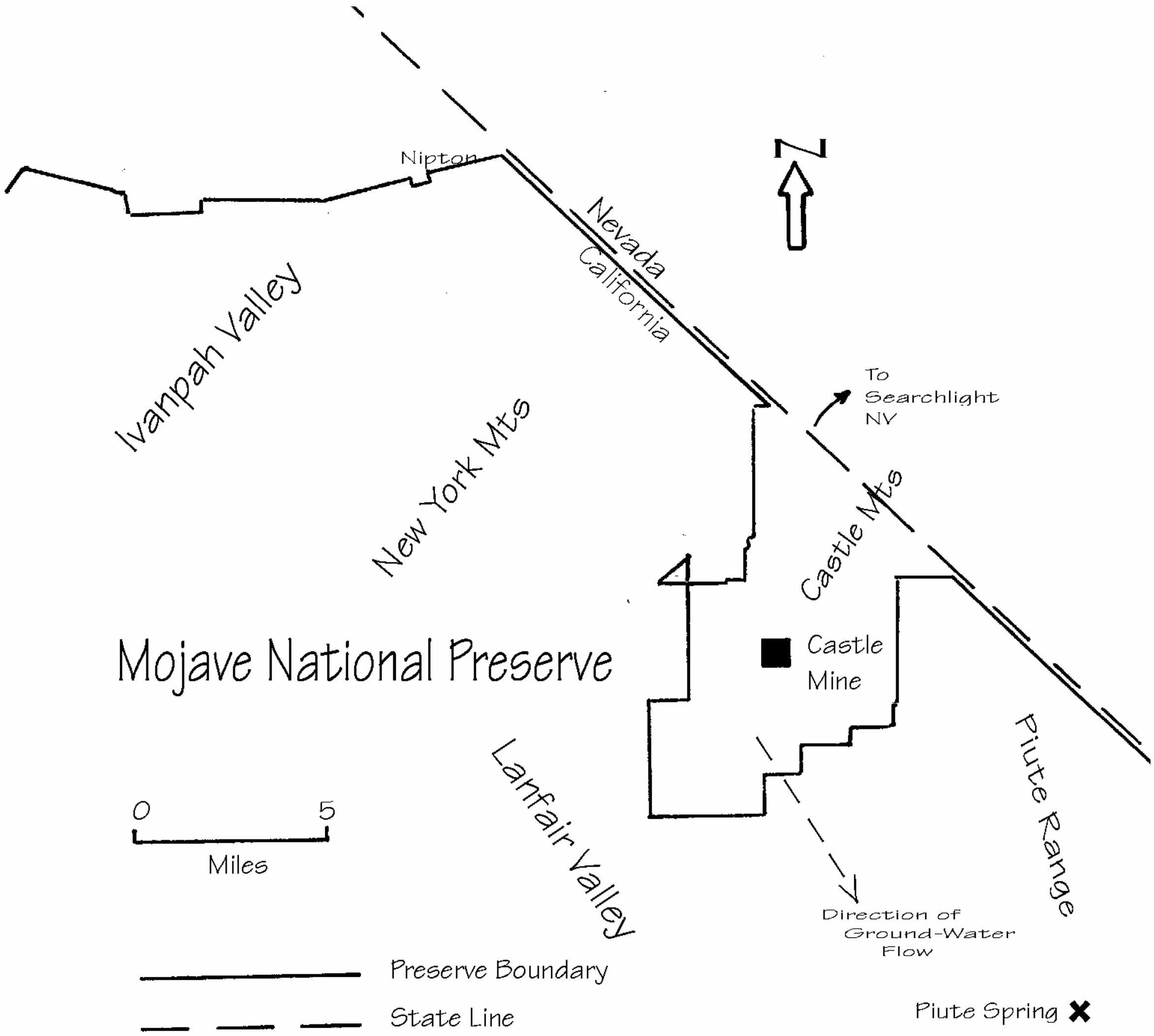


Figure 4.1.b. Sketch of the location of Viceroy Gold's Castle Mine, surrounded on three sides by Mojave NP at the northeastern edge of the Preserve.

The company proposes to expand its mining operation by increasing areas of open-pit mining, creating an overburden storage site, and expanding the existing heap leach pad by 485 acres. Back-filling of the mine pits is proposed on about 158 acres. The mine operating period would be extended 10 years past the currently permitted time, to the year 2010. At the conclusion of mining operations, the total surface area disturbed would be 1,375 acres (Mojave NP, 1998). In October, 1997 a detailed environmental impact statement on the expansion was completed (BLM, 1997). The EIS states, “The *rate* of water use would not change” and therefore “…analysis for the extended operation has … concluded that no effects on Piute Spring would occur.”

Morning Star Mine

This facility is about nine miles southeast of the town of Mountain Pass, in Section 28, T15N, R14E, on the eastern slope of the Ivanpah Mountains, at about 4,500 ft elevation. The mine was first discovered in 1907, and has operated off and on since 1979, depending on the economic viability of a given time. It has been operated intermittently by the Vanderbilt Gold Corporation of Las Vegas, but is idle as this report is being prepared. The mine is an open pit gold and silver mine where ore has been extracted from the open pit and stacked on two heap leach pads. A spray system has been utilized for delivery of a sodium cyanide leach solution to the ore. Leach Pad No. 2 and a corner of the processing plant appear in the photograph of Figure 4.1.c, which looks east from the Ivanpah to the New York Mountains. The ore extraction and processing activities have resulted in approximately 140 acres of surface disturbance.

This economically-marginal mine has had a number of HAZMAT and wildlife violations, with dead wildlife, heavy metal contamination, leaks of cyanide, spilled fuel, and other problems, discussed in the 1996 Final Preliminary Assessment Report, which lists the many concerns raised by BLM & NPS (Sunderland and Yarbrough, 1996). Apparently no Site Investigation has been done; therefore, the site has not been scored for possible inclusion in the Superfund NPL.

The mine was added to the Comprehensive Environmental Response Compensation and Liability Information System (CERCLIS) of EPA in 1994 (CA # 0000466748). BLM nominated the Morning Star Mine for a site evaluation under CERCLA and initiated the notification of hazardous waste site form. The site has the potential to release various pollutants, given the idle leach pads, partially-filled pregnation pond, leftover drums, broken pipes, and probable small dumps. BLM (personal communications) also notes that the mine operators once hauled contaminated liners to the Baker Town Dump. The main pit and other features have the potential to generate acidic drainage.

The site obviously needs some monitoring, and eventually reclamation. It would be desirable to take some samples from the exposed pit and pregnation pond, to determine if cyanide levels hazardous to birds are present (as suggested by the Preserve Geologist). <u>However</u>, it is essential that the sampling be conducted by persons properly trained, suited, and equipped for sampling in a contaminated environment, who can employ the proper protocols for sample handling, shipping, and disposal of the wastes.

Other Mining Activities and Abandoned Mines

A number of other small mines or abandoned mines exists in the Preserve, and the Preserve Geologist is aware of their location and characteristics. Some of these other mines may be interesting from a water perspective. The Colosseum Mine, in the Clark Mountain area, was a gold mining operation that completed its work in the early 90s. Site reclamation work is basically completed, although a huge open pit contains about a 3 acre pool. Some old solution ponds remain (Figure 4.1.d) and the heap leach pads have been reshaped.

Some monitoring continues at the Colosseum Mine, in conjunction with the State's Lahontan Water Quality Control Board. BLM indicates that the Colosseum operation has been basically satisfactory, and is a relatively lower level of concern from an environmental perspective.

A number of abandoned mines have old leach pads, dumps, or other features which could continue to seep, or need some reclamation work. The Preserve Natural Resource Specialist will want to continue to work with the Geologist to identify any sites of concern from a water perspective and recommend some water sampling at certain sites. Project Statement No. 6 proposes a reclamation survey.

Figure 4.1.c. View of hillside leaching facilities at closed Morning Star Mine

Figure 4.1.d. View of ponds used at the closed Colosseum Mine site.

4.2. MAJOR DEVELOPMENT WITH WATER DEMANDS

Development in the Ivanpah Valley

Massive hotels, a gold course, and other major water users are located along Interstate 15, adjacent to the state line. The newly-created casino town of Primm, NV, in the central Ivanpah Valley, is found near the state line. The southwestern headwaters of the closed-basin Ivanpah Valley lie in the Preserve, and the state line cuts across roughly the central part of the valley(Figure 2.2). The small town of Jean lies about 11 miles further northeast, in the Nevada end of the closed valley.

The hotels, golf courses, and other facilities in the Primm area pipe in their water supply from two production wells in California, near the Preserve. The local ground water at Primm reportedly has poor quality and is not used at this time. The golf club plans to utilize existing water wells at the Colosseum Mine (located on BLM lands in the Clark Mountain part of the Preserve) for continuing its operation (personal communications, W. Quinn, Southern Nevada Water Authority, 9/98). The golf course also has a well at T17N/R14E/Sec36, drilled 470 feet deep, with a water table at about 150 feet (GSi/Water, 1998).

The environmental impact report for Molycorp Inc's expansion understandably expresses concern over high water use by a golf course, which "... would likely have a significant cumulative impact on the water supply available in the Ivanpah Valley. Golf courses are traditionally heavy water users..." (ENSR, 1996). The non-native pines, grasses on greens, and other non-arid plants on the golf course doubtless consume enormous quantities of water --perhaps two feet or more a year of irrigation depth. The water is largely lost to either evaporation or transpiration in the arid conditions, while ground-water recharge would most likely be negligible[5].

The Southern Nevada Water Authority (SNWA) maintains a network of monitoring wells in the lower Ivanpah Valley, and over 1,000 observations have been made at about a dozen wells during the late 80s to present (generally monthly) in the Jean and Primm, NV vicinities. The wells, periods of observation, and approximate water levels are summarized in the overview Table 4.2 (Actual data are on file in digital form at the Preserve).

No distinct lowering or raising of the ground-water table was evident in the Primm or Jean areas, from perusing the 1100 observation points of the SNVA data from the last several years. Some variation appeared --presumably related to yearly or seasonal fluctuations or pumping-- but no trend was clear at this time. The Jean area is using about 700 acre feet/year. In Primm, the water supply is imported and the wastewater then spread for recharge or evaporation (discussed with SNWA).

The Town of Jean pumps water from its local wells, which are seen in the Table 4.2.

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[5] In the arid to semi-arid parts of southern Santa Fe County, NM, for example, over 95% of the natural precipitation is used by evapotranspiration, while less than 5% infiltrates (personal communications, hydrologists, Santa Fe County and the University of New Mexico, 1998).

Table 4.2. Overview of the ground-water levels in the Jean and Primm areas (based on Southern Nevada Water Authority data).

Well(s)	Location(s)	Observation Period	Approx. Depth to Water *
NIPR&R	Railroad well near former town of Ivanpah	1990-98	370 feet
NIPTOWN	At town of Nipton	1990-97 (discontinued)	508
GOLDOBS	Observation well (static) near Jean, NV	1988-91	600
"J Wells"	Jean Water District Wells	1990-98 (#J-4) 1995-98 (#J-6E) 1992-98) (Fire well)	550 450 375-450
JGOLD	West of Jean	1988-98	580-725
"M Wells"	A series of 5 monitoring wells in the Primm area, near the casinos	1989(oldest) to fall '97	80-135
"A Wells"	A series of 5 monitoring wells (Old Desert Research Institute wells) near Jean, NV	1987-98	460-545
JRS	Jean Rest Stop (old well, south of Jean)	1988-98	360
JSTATE	Production well NW of Jean	1985-98	450-620

*[Note: A single figure in the right (depth) column is the typical level seen, with about +/- 10 ft of fluctuation. For M and A wells, the range is for the series of wells, grouped together.

The town of Jean uses Ivanpah Valley water from its four production wells. Jean's best wells have an electrical conductivity of about 600-700 micromhos/cm, and the water is potable. Some of the worst well water in Jean however is over 2,000 mmhos/cm, and only used for fire protection (personal communications, Bill Quinn, Southern Nevada Water Authority).

In conclusion:

- The heavy water use from the Colosseum wells by the golf course or others will likely lead to ground-water drawdowns, potentially threatening springs in the Clark Mountain area. (A recommendation is made that the Preserve assess this threat).
- Ground-water quality around Primm is apparently poor, so one can expect developers to seek water in California. (A recommendation is made that The Preserve will therefore want as highest priority a goal to assure and protect its water rights).
- Data from the Southern Nevada Water Authority (SNWA) for the last several years do not show a depression of water tables in the middle and northeastern Ivanpah Valley, at this time.

Cadiz Water Development Plan

The Cadiz Land Company, Inc of Santa Monica has an 50-year agreement with the Metropolitan Water District of Southern California (as of July, 1998) to extract ground water from the Cadiz area and deliver it via a 35-mile pipeline to the aqueduct serving Southern California municipalities. The plan is to start the program in the year 2001, following the necessary reviews. (Cadiz, 1998). The Cadiz or Cadiz Basin area is situated about 10-15 miles south of the Mojave NP, at the lower end of the Fenner and Bristol Basins, as seen in Figure 4.2. The Fenner Basin's headwaters lie in the Granite, Providence and some of the New York Mountains, within the Preserve. (Geoscience, 1995).

According to the plan, Colorado River Aqueduct water can be stored in the aquifer during wetter years, and then in dry years extracted. Some 1,100,000 acre-feet of "Indigenous ground water" in the basin will be transferred out (i.e., a possible average of about 22,000 acre-feet/year –but with enormous variation for wet vs dry years). The project designer's median estimate for ground-water recharge in the large Fenner Basin plus small Orange Blossom Wash is 13-33,000 acre-ft/yr, depending on assumptions used. The Preserve, where the mountain watersheds lie, is the ground-water recharge area.

The project designers estimate potable ground water in storage in the project area at from 12 to 22 million acre-ft (Geoscience, 1995). Over the 50 year life of a project, this would obviously offer a major potential for ground-water mining, depending on how much of this water can be extracted economically (note, in some places around Cadiz, aquifers are thought to be several thousand feet thick; also pumping costs increase as an aquifer is dewatered).

The program will have the capacity to convey, either for storage or transfer, about 100,000 acre-feet in any given year. Up to $150 million will be spent on spreading basins, extraction wells, pipelines, pumps, and other facilities.

The majority of the recharge ("indigenous") water for the project will come from the mountains in the Mojave National Preserve, which is the only part of the basins where precipitation and hydrogeologic conditions provide for significant ground-water recharge (the higher mountains get about 12 inches of precipitation, vs about 3 at Cadiz). In other words, any recharge of "indigenous ground water" for the project must come largely from the Mojave National Preserve. The project's chief hydrologist claims their ground-water storage operation should not affect the Preserve (personal communications, Cadiz Inc, 9/98).

The environmental review process should commence this year, to determine compliance with the California Environmental Quality Act and the National Environmental Protection Act. The project will be conducting a pilot spreading basin test in early 1999 (personal correspondence, M. Liggett, Senior VP, Hydrology, Cadiz, 9/98).

As the prime natural source area of recharge of indigenous water for the project, it is essential that the Preserve be conversant with the environmental analyses and play a significant role in the review process, working closely with the state. Impacts to ground-water withdrawals made by the project on park water sources, related attributes, and NPS rights should be assessed in the environmental review process. Water-related attributes may include wildlife, vegetation, endangered species, livestock, and recreational activities. Does NPS claim a water right for mining purposes? Would the project affect these benefits? A secondary question, from the legal perspective, is the possible effect of the project on the Preserve's water rights.

A related question may relate to the dust created by such a large project, as massive recharge troughs presumably will need to be excavated, and as playa lake basins are possibly dewatered.

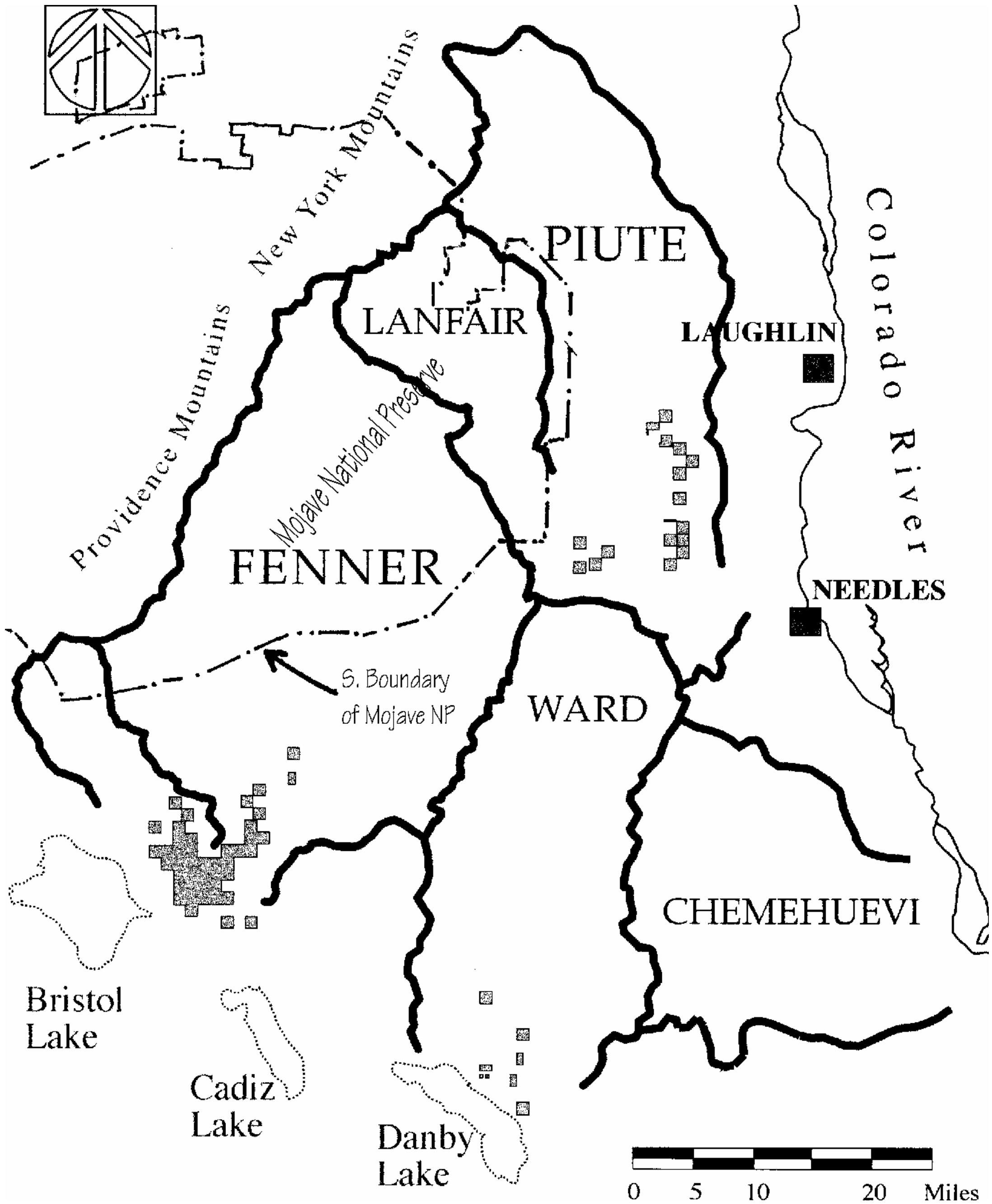

Figure 4.2. Location of the planned Cadiz Inc water resource development in relation to the southern boundary of the Mojave National Preserve (Original map provided to principal author by Cadiz Inc, personal communications, M. Liggett: Preserve name and boundary line was added).

Ranchers in the Preserve area have expressed concern about the Cadiz Inc project, not sure if the proposed project could affect the springs and wells that are the basis for their livelihood.

Other Agricultural Withdrawals

The Cadiz Land Company, discussed above, also has received approvals from San Bernardino County to develop a total of 9,600 acres of agriculture in the Cadiz area. The company owns some 31,000 acres in the area. The company has entered into a 1994 agreement with the Mojave Water Agency (MWA) to potentially transfer water to the MWA for use in other areas that are in "serious and chronic overdraft regarding their current water supply situation." Both the agricultural developments and/or possible transfers of water for other uses would require the pumping of thousands of acre-feet of ground water per year.

4.3. TOXIC MATERIALS AND WASTE

Railroad, Highway, and Petroleum Spills

A major rail line of the Union Pacific Railroad enters the west end of the Preserve near Soda Lake and goes through the hamlet of Kelso, then climbs easterly at a steady 2.2 percent grade along the valley bottom of this wash, until reaching the small settlement of Cima (Spanish for summit). The rail line then drops steadily into the Ivanpah Valley, traversing the Valley's eastern slopes, crossing many arroyos en route, until exiting the Preserve near the community of Nipton, close to the Nevada border.

The trains carry fuels, chemicals, military supplies, and other hazardous materials, so a distinct hazard exists that a track washout and chemical spill can occur and contaminate the Preserve's ground water. Floods have torn out rail lines in the past (Casebier, 1989), and much of the rail line either follows along arroyos or wash bottoms, or crosses arroyos, so the flash flood/train derailment risk is evident.

Essentially two areas of possible aquifer contamination are present: the Kelso Wash and the Ivanpah Valley. A spill at the Kelso area could potentially pollute the ground-water aquifer needed for serving the Kelso community and eventual visitor center. A spill in the Ivanpah Valley could contaminate the aquifer of this valley, which supplies water for development activities along the state line, Molycorp Mine, the Nipton area, and other users.

Major interstate highways follow along much of the northern and southern boundaries of the preserve as well, and truck spills of fuels or chemicals are possible. The direction of ground-water flow at these interstate/preserve interfaces basically is *away from* of the Preserve, so any plume of pollutants would move away from the NPS boundary. Therefore, from a ground-water perspective the truck spills are generally less of a threat to the Preserve's aquifers than are potential train accidents.

The CalNev Pipeline reportedly carries leaded gas and jet fuel in two lines along I-15, from Southern California to Las Vegas. High pressure natural gas also traverses the Preserve, and service crews periodically drain condensed PCBs from the gas lines to truck them away in the field (personal communications, BLM, Needles, 9/98). Precise information is not available on all the pipelines and their materials, and a recommendation is made that better basic information on pipeline routes and substances transported should be assembled, to better evaluate the potential threat.

Given the clear potential hazard for spills, the preserve will want to maintain its contingency plan for containment and cleanup action. Tracking spills is the responsibility of the Hazardous Materials Division of the County of San Bernardino's Fire Department, and the State of California has a Department of Toxic Substances Control office in Glendale, which has a role in hazardous materials issues.

Town Dumps

Only one landfill is located inside the Preserve, the Baker town solid waste facility, which lies approximately 3 miles southwest of the community of Baker. This dump has been closed for several years, and serves as a transfer station. The facility is located on a 40-acre parcel, and of the 40 acres permitted, 12 acres were used for disposal, and 2 acres were used for a burn dump. The facility has received residential, demolition, and commercial refuse, garbage, trash, paper, ashes, construction wastes, abandoned vehicles, old appliances, manure, and animal wastes. An environmental assessment for the landfill was conducted in 1996 (EA Engineering, 1996).

Officially, the site does not receive hazardous wastes or soluble pollutants which would cause degradation of ground water. However, the Morning Star Mine reportedly dumped old pond liners and bag-house dust at the dump, which presumably contained cyanide and other contaminants (personal communications, BLM, 9/98).

From a ground-water perspective, the landfill sits near the edge of the preserve, upslope of the Soda Lake area, some two miles from the preserve boundary. The dump's ground-water flow direction is out of the Preserve; therefore, leakage could affect the two-mile reach within the Preserve's edge.

Ranch Land Dumps and Wastes

A consulting firm prepared a pre-aquisition, environmental site assessment of portions of the Overson Ranches. These are in-holdings covering some 4,726 acres which the NPS hopes to acquire, including acquisition of the water rights to springs and wells. The purpose of the assessment was to identify any environmental liabilities that will be associated with the acquisition. The report identified some petroleum contaminated soils affiliated with oil change and fueling areas, and detected some low levels of pesticides, metals, solvents, and arsenic at individual ranch dumps and old cattle dipping sites, on a small fraction only of the ranch lands. These appear to be minor pollution sources.

The Preserve is preparing a plan for the removal of the contaminated soils, petroleum products, and other potentially contaminating materials that were identified in the ranch study. Specifics on the contaminated sites and materials are listed in the report by Ecology and Environment, Inc (1989). The report's findings suggests that the volumes of fuels and other products identified have not contaminated the aquifers of the ranch areas. However, sampling was not adequate to definitively confirm this impression. Therefore, for any wells intended for eventual use by the Preserve, it would be prudent to confirm acceptable water quality.

The Rail-Cycle Land Fill

Rail-Cycle, a project under consideration for the Cadiz-Amboy area, is a "mega-trash dump" proposed by Waste Management Incorporated for the County of San Bernardino. Waste Management Inc would team up with the Santa Fe railroad to create and fill a dump of approximately 1 mile by 3 miles by 400 feet high. This dump would lie about 10 miles south of the Preserve's southern boundary, near the Cadiz Inc project discussed in Section 4.2. The landfill could handle about 21,000 tons of garbage per day, or about half of Los Angeles county's daily production of 40,000 tons. The dump should have a lifespan of about 100 years --compared to the 13-17 years remaining in Los Angeles County's existing landfills. San Bernardino County potentially could earn $24 million a year through landfill fees(Enviromental Information, Ltd,1996).

The proposed project could still occur, although it has been controversial with environmental groups and strongly opposed by Cadiz Inc (the ground-water development company, discussed in Section 4.3). The Clean Desert Water Coalition (CDWC) points out that Waste Management's gigantic project could potentially contaminate San Bernardino County's water, noting that the Cadiz Aquifer has the potential to supply 100,000 persons with clean water (on line information, CDWC, 1998). The project also has encountered serious legal difficulties in 1998, with an investigation underway by San Bernardino County and the FBI, who have been looking into possible criminal activities by company officials (San Bernardino District Attorney, 5/15/98).

The question arises: will ground water in fact be affected by toxic materials, nutrients, contaminants, and other constituents in the fill? Will the multi-million dollar Cadiz project be at risk? Since the ground water basically flows south, the Preserve's ground water per se should not be directly affected. However, questions regarding traffic, dust, and other impacts could concern the Preserve.

Ward Valley Low-Level Nuclear Waste:

A national dump site for low-level radioactive wastes and radionuclides with short half-lives is proposed for the Ward Valley area, about 10 miles southeast of the Preserve's southeast corner, or some 25 miles west of Needles. The project has been approved by the state, and awaits federal approval. U.S. Ecology, Inc is the license-designee (Mojave NP, 1998).

The project would consist of a 90-acre disposal and support area, within a greater 1,000-acre buffer zone. Property ownership would transfer from the BLM to the State of California. The waste would be placed in containers, then buried in trenches, for a period of 30 years operation. No hazardous or high-level wastes would be accepted. A final environmental impact report/environmental impact statement for the project was prepared by Dames and Moore Company in 1991 (Mojave NP, 1998).

Controversy has occurred, with conservation groups claiming that the plan could lead to disposal of "dangerous radioactive wastes in unlined trenches" (Ward Valley Coalition, 1998).

Some aquifer contamination could be possible, but presumably outside the Preserve. The aquifer of the valley flows south to Danby Dry Lake, and ground-water levels are shallow in the valley (less than 40 feet) in many places. Some ground-water movement between valleys in the area is possible, since alluvium material goes to a great depth

(Thompson, 1929). The ground water in the area should move south, away from the Preserve. The Piute Mountains, a small range, are the barrier between the Preserve's easternmost Fenner Valley and Ward Valley.

This is a proposal which the Mojave NP will want to follow. Aquifer contamination could be a concern, although the Preserve appears to be upslope in ground-water terms, and –at first impression—not in line with contamination movement.

4.4. FLOODING

As noted in Section 2.3, Hydrology, localized surface runoff or summer flash flooding can be intense during storm periods, and certain arroyos or washes can present flood hazards to people or structures. For example, several floods have taken place at the small community and old Depot at Kelso, and a levee system is in place for protection.

The Mojave National Preserve's policy is that the occupancy and modification of floodplain and wetland areas would be avoided; however, where no practical alternatives exist, mitigating measures should be implemented to protect life, property, and natural floodplain and wetland values (Mojave NP, 1998). Certain sites in the Preserve appear to require mitigating measures.

The Water Resources Division (WRD) of the National Park Service conducted a floodplain survey and floodplain analysis at the Kelso Depot, Hole in the Wall Campground, and Mid Hills Campground areas in the spring of 1998 (Martin & Smillie, 1998). The Kelso Depot is an abandoned Union Pacific Railroad depot, located in a broad alluvial valley between two extensive coalescing alluvial fans, at the eastern edge of the Kelso Basin shown in Figures 2.2.a and 3.5. The depot lies in the floodplain area. Kelso Wash is within the Kelso Basin, draining approximately 250 square miles. The Mojave NP plans to convert the old Kelso Depot into a visitor center; therefore, it is essential to assess the flood hazard of the site, especially since the Kelso area has experienced flooding.

An existing levee upstream and downstream of the Kelso Depot area extends for several thousand feet in both directions, standing about seven to nine feet high above the channel bottom. Local inhabitants have seen floods rise close to the top of the present levee.

Martin and Smillie (1998) of the Water Resources Division (WRD) surveyed cross-sections along the channel and determined elevations, slopes, and other topographic details. They then estimated design flood discharges with regional regression equations available from the U.S. Geological Survey, with prime focus on the 25 square miles immediately upstream of the project site. Discharges were estimated for recurrence intervals of 2, 5, 10, 25, 50, and 100 years, and for the extreme flood, determining water elevations and velocities for each design flood (except extreme flood), using a HEC-RAS model.

Martin and Smillie's analysis indicated that 2- up to 10-year floods (19-826 cfs) would be contained, but that discharges above the 10-year flood level would begin to erode the existing levees and flood the Kelbaker Road. A 25-year flood (3,115 cfs) would flood the ground level of the depot and damage the levee, while a 100-year flood (10,616 cfs) could breach the existing levee, cause serious flooding, or endanger lives. Therefore, the 1998 WRD work recommended flood mitigation for the Kelso Depot area, advising on structural protection up to the 100-year flood, plus a flood warning system.

The WRD crew also analyzed the Hole in the Wall Campground area, determining that a 100-year flood there would partially inundate the campground. The location of the campground also would make escape difficult during an extreme event. The campground is marginally within the 100-year floodplain.

In view of Martin and Smillie's analysis and interpretation, it is recommended that the Preserve staff will need additional hydraulic engineering assistance from the Water Resources Division (WRD). WRD advice would be valuable as the Preserve staff develop the flood mitigation designs for the Kelso Depot area's levee, a warning system, and any flood mitigation work which the Preserve want to conduct at the for Hole in the Wall Campground. WRD advice could help the Preserve develop a proper design incorporating high effectiveness, reduced costs, and efficient maintenance.

Additional technical assistance also will be needed at the Zzyzx area, to evaluate the flooding potential at the ponds which serve as the habitat for the endangered Tui chub, as discussed in Section 4.8. It now appears that a large flood could potentially wash out these ponds and possibly eliminate the small, remnant population of Tui chub. Advice would be needed on the type of levees or other structures needed to protect these small impoundments. Advice also will be needed on how to provide "flash flood awareness" for park visitors and staff, since this type of environment can produce dangerous flood conditions that are not anticipated by the general public.

4.5. WATER RIGHTS

California Water Rights

When the Preserve was established in 1994, the NPS acquired many water rights on the lands which comprise the Preserve. These water rights were previously held by a variety of land owners, including other Federal agencies, corporations, and private individuals. The NPS must evaluate these rights, and make the necessary changes or corrections to make these rights consistent with NPS uses. This is necessary since the State of California requires the holder of an appropriative water right to accurately report water use every three years for each water right. If the use is not reported, the NPS risks forfeiture of the right.

The State of California recognizes both appropriative and riparian water rights. Appropriative water rights are considered property rights where the party who first appropriates the water and applies it to a beneficial use has a prior right of use against all other appropriators. Recognized beneficial uses include such activities as municipal, irrigation, mining, recreation, and preservation and enhancement of fish and wildlife uses. Appropriative water rights used before 1914 are not subject to the licensing and permit program that post-1914 water rights are. Post-1914 water users are required to file Statements of Water Diversion and Use with the State Water Resources Control Board (SWRCB) at regular intervals. Pre-1914 rights are also required to do so, however there is no penalty for not filing. However, without the Statements, it may be difficult to document continuous use of the water, which may be required if the right is disputed (summarized from Johns, 1993).

Riparian rights are associated with lands adjacent to a stream or other body of water. These rights include the right to divert and use water on the land, but not to store it. Riparian rights also can not be lost due to non-use. The United States is entitled to riparian rights the same as any other land owner. However, for non-reserved lands, the riparian rights of the United States are subordinate to the rights of appropriators established under State law (Dunning, 1991).

Riparian rights would also apply to water from springs. However, water from springs or standing pools that has no natural outlet belong to the owner of those lands and may be used without permit (Hill, 1993).

California separates ground water into "percolating" ground water, or water which flows in a known and definite channel or is the underflow of a stream. The second case requires a Statement of Water Diversion and Use for a riparian use (use overlying land) or a permit for an appropriative right (use not overlying on land) (Johns, 1993). If the water is considered percolating, the SWRCB has no jurisdiction over the water withdrawal.

The Preserve is located in San Bernardino County. Since 1955, anyone extracting ground water in San Bernardino, Riverside, Los Angeles, or Ventura counties in amounts over 25 acre-feet per year is required to file a notice with the SWRCB describing details of the withdrawal. However, this notice is not provided to the public and there is no opportunity to protest or object to the withdrawal with the SWRCB. The county of San Bernardino does require a permit to drill a well, which is issued to the State licensed well driller responsible for drilling the well.

Federal Reserved Water Rights

When the government reserves land for a Preserve or other purposes, it also reserves, explicitly or by implication, enough unappropriated water at the time of the reservation as is necessary to accomplish the purposes for which Congress or the president authorized the land to be reserved. Therefore, the United States is entitled to Federal reserved water rights for Preserve lands that have been reserved from the public domain. The quantity of water associated with this right is that amount necessary to accomplish the purposes for which the land was reserved. The California Desert Protection Act of 1994 (Section 2,b,1) identifies the following purposes:

"(1) appropriate public lands in the California desert shall be included within the National Park System and the National Wilderness Preservation System, in order to:

(A) preserve unrivaled scenic, geologic, and wildlife values associated with these unique natural landscapes;

(B) perpetuate in their natural state significant and diverse ecosystems of the California desert;

(C) protect and preserve historical and cultural values of the California desert associated with ancient Indian cultures, patterns of western exploration and settlement, and sites exemplifying the mining, ranching and railroading history of the Old West;

(D) provide opportunities for compatible outdoor public recreation, protect and interpret ecological and geological features and historic, paleontological, and archeological sties, maintain wilderness resource values, and promote public understanding and appreciation of the California desert; and

(E) retain and enhance opportunities for scientific research in undisturbed ecosystems."

Federal reserved water rights for wilderness areas are specifically established in the Desert Lands Protection Act. Title VII, Section 706 states:

"(a) Except as otherwise provided in section 204 of this Act, with respect to each wilderness area designated by this Act, Congress hereby reserves a quantity of water sufficient to fulfill the purposes of this Act. The priority date of such reserved water rights shall be the date of enactment of this Act.

(b) The Secretary and all other officers of the United States shall take all steps necessary to protect the rights reserved by this section, including the filing by the Secretary of a claim for the quantification of such rights in any present or future appropriate stream adjudication in the courts of the State of California in which the United States is or may be joined in accordance with...the McCarran Amendment (43 U.S.C. 666).

(c) Nothing in the Act shall be construed as a relinquishment or reduction of any water rights reserved or appropriated by the United States in the State of California on or before the date of enactment of the Act.

(d) The Federal water rights reserved by this Act are specific to the Wilderness area located in the State of California designated under this Act. Nothing in this Act related to the reserved Federal water rights shall be construed as establishing a precedent with regard to any future designations, nor shall it constitute an interpretation of any other Act or any designation made thereto."

Federal reserved water rights established for other NPS units have included such uses as water for wildlife, riparian vegetation, fish, and for park administration and visitors. The amount of water required for these uses would need to be determined for each water source that a reserved water right would apply. To prepare for the possibility of claiming Federal reserved water rights, the NPS should conduct an inventory of all water sources found within the Preserve and determine which of these sources are located on reserved lands. [Note the Project Statement on water sources on p 61].

As mentioned above, the United States may need to quantify its Federal reserved water rights during a water rights adjudication. This is a court-ordered proceeding whereby all water right holders within a specified area assert their right to use the waters of the State. Rights in the area of the Preserve have not been adjudicated and is not known when this action will occur. However, the NPS will oppose any water right application or well development that it determines may affect the NPS's inchoate Federal reserved water rights.

Acquired Water Rights

When the Preserve was created, the NPS initiated correspondence to acquire water rights previously used by the Bureau of Land Management. These negotiations are still underway as this report is prepared.

A list of these water rights (155 entries), from the State's Water Resources Control Board, Division of Water Rights, is presented in Appendix 2. Presently, the WRCB's records list the owner of these water rights in the name of the previous users. When the NPS has determined that it will acquire and maintain a water right, they should record the change in ownership with the WRCB and make any other corrections to the water rights records that may be necessary

Future Water Right Acquisitions

The NPS may acquire many more water rights as lands are purchased and included in the Preserve. During the acquisition process an analysis is recommended to determine whether associated water rights should be acquired. The NPS will not acquire water rights where these rights are not needed to protect water uses.

Over 200 wells in San Bernardino County are recorded as being included within the Preserve boundaries. As mentioned above, wells do not fall within the jurisdiction of the SWRCB unless they withdraw water from a known and definite channel or is the underflow of a stream. There are 15 wells listed in Appendix 2 that have been filed with the SWRCB. If the NPS acquired these wells, changes will need to be filed with San Bernardino County and the SWRCB to provide the correct owner for wells. Other wells not needed will need to be properly abandoned according to State procedures.

Protection from Non-NPS Ground-Water Withdrawals

As stated above, several developments are proposed near the Preserve. These developments may divert water that supplies spring flows or water for Preserve resources. The NPS can file protest to the State if park water rights will be affected by outside park diversions only if these diversions require a permit and license by the SWRCB. If necessary, the NPS will seek protection of its riparian or Federal reserved rights through the courts to ensure that NPS water rights and resources are not adversely affected. Ground-water withdrawals in Nevada may also adversely affect water resources within the Preserve.

Summary of Water Rights-Related Tasks

To summarize water rights needs, a brief list of water rights-related tasks follows:

- Inventory all documents related to water rights in the Preserve that were acquired when the Preserve was created.
- Change record of ownership of these rights to ensure that NPS is the right holder and request other corrections to the rights to accurately reflect NPS's use of water.
- Determine if NPS needs to properly dispose of unused water rights.
- For future land acquisitions, analyze potential water right acquisitions to determine if they are needed by the NPS and include the appropriate language in the contracts of sale to secure the rights.
- Conduct an inventory of water sources within the Preserve to determine NPS's Federal reserved water rights.
- Prepare a strategy to protect NPS water rights and water resources from the effects of ground-water withdrawals by non-NPS users in California and Nevada.

The Water Resources Division, Water Rights Branch will work with Preserve staff to accomplish the above tasks.

4.6. QUESTIONS ON MANAGING GUZZLERS AND TANKS

As discussed in Section 3.2, a guzzler is a low-maintenance, permanent self-filling water catchment device that catches and stores storm runoff in a tank, from which wildlife can drink. Ranching and mining over the years also have introduced many artificial water devices to the desert, and flows from springs and seeps have been diverted and the water piped to tanks. Wells, windmills, troughs, and other devices are still present, and provide water to cattle, burros, and wildlife (Mojave NP, 1998).

More than 100 artificially-developed water sites exist in the Preserve, including piped livestock tanks, troughs, six big game and 133 game bird guzzlers. The 133 guzzlers were developed by the California Department of Fish and Game, the Bureau of Land Management, and volunteers before the area was designated a National Preserve in 1994. The six big game guzzlers provide water for bighorn sheep (Figure 3.5).

The Mojave National Preserve needs to examine the management of guzzlers, livestock tanks, troughs, and other artificial water devices, and analyze how best to use these artificial facilities in harmony with NPS philosophy of allowing nature to take its course wherever possible.

Analysis is needed to assess the benefits, disadvantages, impacts, and suitability of these water developments in the Preserve. As with the guzzlers, the Preserve needs a policy on the use of these water developments, including field guidelines to determine when it is appropriate and beneficial to maintain or improve these facilities, and when it is best to phase them out.

In summary, the Preserve needs to examine the use and need of all water site developments, and to develop a program which will enhance conditions for the protection of native plants and wildlife. The NPS should seek to restore natural water sources to be self-sustaining, as far as possible, and a longer-term goal may be to remove artificial water facilities from sites where a more natural sustainability is possible (Mojave NP, 1998).

4.7. EXOTIC VEGETATION AND ANIMALS AND THE WATER RESOURCE

Exotic species include both plants and animals, which generally are species occurring due to human actions, either deliberate or accidental. Obvious examples in the Preserve include burros and plants such as tamarisks (salt cedar).

Salt Cedar (Tamarisk)

The tamarisk (Tamarix ramossissima) or salt cedar, an introduced shrub or small tree 5 to 20 feet tall, is an opportunistic invader of moist areas. The Bureau of Land Management and the National Park Service have ongoing control programs to attempt management of this invasive plant (Mojave NP, 1998). Tamarisks can invade seeps, springs, and riparian areas in desert areas, where they transpire large volumes of water, compete with native vegetation, and provide few of the wildlife benefits afforded by native species.

It is still a common perception among many biologists that the replacement of a dense thicket of salt cedar by a mixed ecosystem could reduce water waste in certain sites, perhaps in seep areas. Salt cedar pump great quantities of water, and persons with experience in the Mojave Desert believe they have observed particular seeps or spring areas return to wetter conditions after tamarisk removal (Personal communication, W. Yumiko, BLM, 8/98).

There is some disagreement as to how much water salt cedar in fact uses and how its transpiration compares to that of native vegetation, especially since field experiments on this question are at best difficult. Tom Bilhorn (personal communications, April, 98), who has researched tamarisks in the Mojave Desert area for many years, believes that water use is not a justification for removing these exotics. He has observed sites where the water use by salt cedar was roughly comparable to that of a cottonwood/willow stand (Lines and Bilhorn, 1996). However, Bilhorn notes that tamarisks are still worth removing, to stop their massive, invasive areal spread, to keep riparian ecosystems natural, and to gain a variety of wildlife benefits. More precise research information on tamarisk transpiration rates and the benefits of removal would be valuable.

Curt Deuser of Lake Mead National Recreation Area, NPS specialist on exotic tree eradication, has visited the Preserve on several occasions during 1996-98, to assist in the eradication of tamarisk trees. The BLM also attempted to remove tamarisk when the area was under their management (personal communications, W. Yumiko, BLM, 8/98).

From a wildlife habitat viewpoint, it would be worthwhile to continue a tamarisk eradication program.

Burros

Wild burros are known to contaminate water sources through defecation and urination, and by overbrowsing they can eliminate natural aquatic and riparian vegetation. Burro destruction of riparian habitat indirectly affects bird species, since the natural spring areas and seeps provide essential foraging and nesting habitat.

Loss of riparian habitat is the major factor influencing the decline of southwestern willow flycatcher (*Empidonax trailli extimus*), the least Bells vireo (*Vireo bellii pusillus*) and the California/western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), which are endangered, riparian-dependent bird species in the area.

Burros can monopolize springs or seep areas and the water. On average, a burro consumes about 22 liters (5 gallons) of water per day, compared to 3.8 liters (1 gallon) per day for bighorn sheep (Mojave NP, 1998).

Continuing a program to reduce numbers of burros is clearly important and beneficial from the perspective of protecting wildlife, watersheds, ecosystems, and water quality.

4.8. NATIVE FISH AND WILDLIFE ISSUES

The Mohave Tui chub (*Gila bicolor mohavensis*) is a fish in the minnow family that can reach over 10 inches in length. It is the only fish native to the Mojave River basin in California. In 1970, the Mohave Tui chub was listed as an endangered species by the U.S. Fish and Wildlife Service (Mojave NP, 1998).

A small population of Mohave Tui chub, believed to be genetically pure, was found at a small pond (about 6 feet deep and 9 feet in diameter) at Soda Springs on the western bank of the dry Soda Lake. The population continues to survive in 1.4 acre Lake

Tuendae, the largest constructed pond, and in two smaller ponds nearby. Since its rediscovery, populations also have been introduced to constructed ponds at Soda Lake, Camp Cady, China Lake Naval Weapons Center, and the BLM's California Desert Information Center in Barstow. Between 10,000 and 20,000 fish live in these four areas (Mohave Tui chub recovery team meeting, November, 1996; Mojave NP, 1998; Archbold, 1994; Mohave Committee, 1988). [See Figure 3.2, Soda Lake].

A concern exists that the Tui chub populations in the small ponds could be at risk from an extreme flood. As discussed in Section 2.3 on flooding, in rare flood years the Mojave River has made it downstream to flood the Soda and Silver Lakes area, for example in 1938. Such a flood also would inundate the Tui chub location at Soda Lake, and increase the chance of the ubiquitous non-native Arroyo chub (now occupying all of the Tui chub's former habitat) in interbreeding, and essentially eliminating, the Tui chub. However, it is not known if a significant flood risk still exist, given the major changes upstream on the Mojave River in the last few decades, including new dams and the much heavier use of water (see Section 2.3 and Figure 3.2).

Technical assistance is needed to (1) evaluate the flood risk at Lake Tuendae at present, and (2) if flood risk is evident, advise on protective measures, such as levees.

5. RECOMMENDATIONS

5.1. GENERAL RECOMMENDATIONS

Introduction

This section (5.1) presents recommendations and broad ideas for *possible* water resource activities, projects, or actions --including both small and large-scale items. This list may be useful as a framework for water resource planning and discussion of goals.

Section 5.2 then lists four *Technical Assistance (TA) Requests* for help needed at this time. These four TA requests were submitted to the Water Resources Division in September, 1998.

Finally, Section 5.3 provides six ideas for some possible projects in the form of *Project Statements*.

The general menu of recommendations below is grouped by category. Certain items judged especially important at this time are flagged as "a high priority" in the list below. Also, several important items are included in 5.2., *Technical Assistance Requests* or expanded into one of the 5.3., *Project Statements*. The six Project Statements are prioritized. Some actions already underway or planned at the Preserve also are recognized as valuable by their inclusion in the list.

Mapping, Surveys, and Data Merging (a high priority need at this time)

1. Develop a credible map and database of the water sources in the Preserve.

   Background: A dozen or more maps and lists of springs, wells, and guzzlers exist for the Preserve area, as described at length in this report. However, the quality of these materials is variable and sometimes poor. One technically credible map plus database is needed. *Technical Assistance Request No. 4* requests help on the "initial design" phase of a mapping project, while *Project Statement No. 1* proposes the actual project.

Designing and Initiating General Monitoring

1. Design and initiate a ground-water monitoring and wildlife water source network for the Preserve

Background: If the large ranchland acquisition is finalized as anticipated, (Section 3.2), the Preserve can use the acquired springs and wells to develop a valuable and needed ground-water monitoring network. The recommendation for this network is described in *Project Statement No. 2.*

2. Initiate a simple, staff/volunteer monitoring program for springs

Background: *Project Statement No. 2* recommends designing and initiating a ground-water monitoring network. In addition, the Preserve should initiate a simple monitoring program for springs. At this time, data on spring flow are limited and dated. A simple but useful database of spring flows could be conducted with field staff or volunteer participation. The details on this recommendations appear as part of *Project Statement No. 2.*

Active Mines (a very high priority concern at this time)

1 (a). In conjunction with the BLM (Needles office), the County of San Bernardino (San Bernardino/Victorville), and the Regional Water Quality Control Board (Victorville), request the Environmental Protection Agency to conduct analyses on the Molycorp Mines. The Preserve would participate as a key reviewer.

1 (b). Integrate the Preserve role into the process of oversight and investigation of active mines, especially for Molycorp, by asserting responsibilities as natural resource trustees under CERCLA. Also coordinate these efforts with the Environmental Quality and Water Resources Divisions of the NPS.

Background: A state Environmental Impact Report apparently has not been finalized, and no U.S. Environmental Protection Agency "ranking score" for Superfund Sites has been done at the Molycorp Inc mines (communications, BLM, 1998). (Re: Section 4.1).

2. Seek technical assistance to analyze the monitoring plans, routine sampling, water sampling efforts, and water quality models underway for Molycorp Inc's mining area – many which are complex.

Background: The Molycorp operation is the largest potential water quality threat in the Mojave NP area. NPS/Washington Office adviser Heather Davies' has provided valuable coordination with BLM and other agencies (now transferred to the USDI). Specialized technical assistance from the NPS Water Resources Division will be valuable to assess the monitoring and models, which are complex. *Project Statement No. 4* provides further details.

3. Continue to review the technical reports from Viceroy Gold on the quantity and quality of Piute Spring flows. Eventually incorporate the data into the Preserve database on springs suggested in *Project Statement No. 2.*

> Background/Comments: Viceroy's monitoring appears appropriate, but it would be useful if a water quality specialist could review the existing analyses, to determine if the sampling is statistically adequate to detect impacts (a possible technical assistance request for 1999).

Abandoned Mines

1. Analyze the abandoned mines in the Preserve to identify those sites where reclamation would be appropriate. Develop a plan for the reclamation (proposed in *Project Statement No. 6)*.

> Background: Abandoned mines have old leach pads, dumps, or other features which could continue to seep or present hazards. The Preserve Natural Resource Specialist will want to continue to work with the Geologist to identify any sites of concern, including <u>proper/safe</u> sampling of water for cyanide in pits or ponds.

Development Projects and Possible Impacts (a growing, high priority concern)

1. Determine the volumes of water used or predicted for major projects and potential impacts on the Preserve. *Project Statement No. 3* proposes an analysis of the potential effects of projects of this type.

> Background: Heavy water demands from projects such as the Primm Golf Course in the Ivanpah Valley or (potentially) the Cadiz Project in the Fenner Valley could affect Preserve springs or wells.

2. Follow development of the Cadiz Land Inc water project, and play an active role in the environmental review process (presumably starting in early 1999).

> Background: *Technical Assistance Request No. 3* requests help on hydrologic interpretation of the technically complex Environmental Impact Statements expected on the Cadiz project, probably in a matter of months. *Project Statement No. 3* includes consideration of the Cadiz project as well.

Water Rights (a very high priority concern at this time)

A summary of six categories of water rights-related tasks is presented in Section 4.5, on Water Rights. Two specific items are highlighted here (see Section 4.5 for the other items).

1. Confirm and finalize the water rights allocations associated with ongoing transactions for ranchland acquisition and with the transfer of water rights from BLM to the NPS.

> Background: Assistance is needed from the NPS's Water Resources Division to advise and assist the Preserve on the acquisition of water rights related to land donations to the Preserve --expected to occur, and to include the appropriate language in the contracts of sale to secure the rights. *Technical Assistance Request Number 1* in Section 5.2 of this report covers this topic (the request went to the Water Resources

Division of NPS in September, 1998). Advice may also be needed on BLM transfers to NPS.

2. Prepare a strategy to protect NPS water rights and water resources from the effects of ground-water withdrawals by non-NPS users in California and Nevada (mainly by nearby development projects).

Background: *Project Statement No. 3* proposes an assessment of the potential impacts of the major development projects near the Preserve, including the water rights aspects.

Cooperative Research

1. The Preserve should encourage the U.S. Geological Survey to conduct cooperative research to characterize and quantify ground-water recharge processes in the basins of the Preserve and to assist on the interpretation of ground-water withdrawal and recharge.

Background: The issues raised in this paper concern ground water in almost every instance. Yet these issues cannot be analyzed or interpreted adequately without an understanding of ground-water levels, seasonal fluctuations, recharge processes, volumes of recharge, characteristics of aquifers, rates of water movement, and other factors. Knowledge of these factors for the Preserve is only fair. Knowledge of recharge per se is poor. *Project Statement No. 5* is a workshop aimed at this topic.

Hazardous Materials and Pipelines

1. Visit the BLM Needles Office, to copy existing hand-drawn field maps of water pipelines for the Preserve area, on hand in that office. (This is information of value to the Preserve).

Background/Comments: More precise information is needed on the location of petroleum-product pipelines traversing the Preserve, to identify most likely spill sites and understand the character of the threat (Re: Section 4.3).

2. Maintain a contingency plan for railroad spills in the Kelso and Ivanpah Valley areas.

Background: As described in Section 4.3, a major railroad line presents a clear potential for rail washout and derailment during flash flooding.

3. Analyze the Kelso Depot area for contaminants via a wellhead protection approach, whereby sources of contamination are identified within the area that would contributes water to an eventual new NPS well.

Background: BLM contacts in Needles mentioned that Kelso has two old 10,000 gallon septic tanks underground (collapsing), old underground acid tanks, probable past chemical spills from train maintenance, old dumps, and other potential contaminants that may exist.

Flood Hazards

1. Finalize the flood protection design and construction at Kelso (a high priority concern).

Background: Water Resource Division technical advice is needed to help Preserve staff develop the flood mitigation and warning system for the Kelso Depot area, to develop a system with effectiveness, reasonable costs, and efficient maintenance. At the same time, WRD could provide additional advice on flood mitigation for the Hole in the Wall Campground area (*Technical Assistance Request No. 2*; discussed in Section 4.4). Advice also will be needed on how to provide “flash flood awareness” for park visitors and staff, since this type of environment can produce dangerous flood conditions that are not anticipated by the general public.

2. Request technical assistance evaluate the flood risk at Lake Tuendae at Soda Lake, to determine if a flood risk exists, and advise on protective measures if needed.

Background: A small population of genetically pure Mohave Tui chub live at Lake Tuendae and some small ponds on the western bank of the dry Soda Lake. An unusually high flood could possibly flush out these ponds, eliminating the population (discussed in Section 4.7).

Biological Aspects

1. Continue with the tamarisk eradication efforts. Request Lake Mead NRA for continued assistance.

Background: Curt Deuser and team of Lake Mead NRA has visited the Preserve to remove tamarisks (salt cedars), as discussed in Section 4.7.

2. Continuing a program to reduce the numbers of burros.

Background: Burro reduction is beneficial from the perspective of protecting wildlife habitat, controlling watershed erosion, protecting natural ecosystems, saving water, preserving water quality, and protecting the natural habitat around seeps and springs.

3. Request that the Biological Research Division of the U.S. Geological Survey in Flagstaff provide technical advice on the management of guzzlers (they have done similar work in northern Arizona National Parks).

Water Supply

1. In 1999, request some technical assistance from WRD for advice on installation of a new well needed at the Hole in the Wall area (Section 3.6 provides discussion on this point). A water supply specialist needs to review the water supply situation at Soda Lake as well.

5.2. TECHNICAL ASSISTANCE

In September, 1998, the following four technical assistance requests were prepared and forwarded to the NPS Regional Office, for their submission to the NPS Water Resources Division, in Fort Collins.

5.2.1. Title: Provide water rights advice on (i) land purchases and (ii) ground-water withdrawals at MOJA.

Task: (I) Evaluate land acquisitions underway and advise MOJA on approaches and appropriate language needed to transfer water from BLM and others, evaluating title and other documents. (ii) Review ongoing commercial water withdrawals and mining use of water to determine if these activities could threaten the Preserve's water rights. Help MOJA develop a strategy for the protection of water rights.

Background: (i) The Mojave National Preserve is in the process of acquiring land from BLM and others, and needs to assure proper transfer of water rights for beneficial uses in the Preserve. (ii) Secondly, major development activities on the park's periphery include a golf course, mining, ore processing, casino construction, and other actions which can withdraw large volumes of ground water . The effects of these withdrawals on the Preserve's water rights are not known.

5.2.2. Title: Assess the hydraulic aspects of mitigation proposals for flood protection.

Task: Review the flood mitigation procedures and designs planned at Kelso Depot (levee and warning system) and any flood mitigation planned for Hole in the Wall Campground. Advise the staff on any improvements in design to increase effectiveness, reduce costs, or provide for more efficient maintenance.

Background: WRD provided technical assistance in 1998, which determined that flood mitigation work is needed. WRD's July 9, 1998 Memo to MOJA recommended that technical assistance follow-up would be valuable, to assist MOJA in developing appropriate mitigation designs.

5.2.3. Title: Review the impacts of commercial activities on Mojave NP's ground water.

Task: (A). Review on the ground and in documents the potential impacts of activities on MOJA's springs or wells. Activities include: (i) major ground-water withdrawals planned for metropolitan use, just south of MOJA, with potential effects on the Preserve's springs; and (ii) the heavy withdrawal of water and waste disposal by mining on MOJA's eastern edge, with potential ground-water overuse or contamination. (B). Refine the Project Statement to prescribe how MOJA can best assess the occurring or potential impacts.

Background: A water resources scoping exercise at MOJA in 1998 is helping MOJA identify these potential impacts and draft preliminary proposals. However, help is now needed from a ground-water specialist to develop and cost out technically sound project statements for submission to WRD or others.

5.2.4. Title: Locate sources of water within Mojave National Preserve.

Task: Request assistance from the Water Operations Branch, Water Resources Division, in locating water sources in Mojave National Preserve. These sources include wells, springs, seeps, and guzzlers. The location of the water sources will be cross-referenced with previously published maps to check for accuracy and completeness. Sources will be located using a differentially corrected Global Positioning System (GPS) accurate to within one meter. Final output will be in a format compatible with Mojave National Preserve's Geographic Information System (GIS). Request assistance from the Water Operations Branch in: (1) the design of methods for the inventory; (2) assistance in the supervision of the inventory and; (3) review of the results and identification of any future work. Conduct the inventory with the assistance of a local university or under a contract with a consulting firm (*Project Statement No. 1*).

Background: The Preserve has no central database or accurate map of its water resources at this time. This effort will also provide a prototype for conducting water resource inventories at other parks.

5.3. PROJECT STATEMENTS

Project Statement 1. Park Priority 1 of 6

Title: Locate and Map Water Sources in the Mojave National Preserve

Funding Status: Funded: 0 Unfunded: $35K

Problem Statement

The Mojave National Preserve does not have a verified map of its springs, wells, guzzlers (animal watering tanks), and other water sources. The various maps available of these water features are largely based on old surveys or field estimations, some dating back to the 1920s. Locations of water features therefore are often approximate, since few of the sites in the Preserve have been pinpointed with global positioning or modern survey techniques.

Springs, wells, and guzzlers provide the only significant water resources in the Mojave NP, since no significant permanently flowing stream lies inside the boundary.

It is important that Preserve managers have a correct map and database of the water features as a basic management tool. This information, now inadequate, also is fundamental to good planning or assessment of any environmental impacts on the springs and ground water in the Preserve.

Description of Recommended Project or Activity

It is proposed to prepare a verified map, plus manual, of the springs, wells, windmills, tanks, big-game guzzlers, and other key water features within the boundary of the Mojave National Preserve. The project also would provide data suitable for GIS use.

The accompanying manual would include: descriptions of how to find each site, a digital photograph, notes on any special characteristics; and any existing information on flows, water quality, or other information.

The project approach basically would consist of the following steps:

- Assemble and review all maps, geographic information databases, surveys, and other information on the location of water sources in the Mojave NP;
- Compare the maps and data, to identify the location of the water features from the best maps; review maps with local historians, ranching "old timers," and other locals;
- Select the best existing data and maps of the group for reference in the field;
- Set priorities for which sites to visit in the field, in case time is inadequate to visit all locations the first year;
- Visit the springs, wells, and big-game guzzlers in the field, armed with global positioning system, air photos, the best maps, etc, to conduct GPS surveys (can be up to 200 sites);
- Finalize the map;
- Provide the information in a format suitable for updating and correcting the water points in the existing GIS database of the Preserve.

The Bureau of Land Management, which manages surrounding land, had a team conduct a Global Positioning System survey of springs on the ground, near the Preserve about 1994-95. These surveys were digitized into ArcInfo. The team conducting the survey work for the Preserve could review the records, processes, results, and techniques used by the BLM to benefit from their experience in carrying out the same type of project in very similar terrain.

The basic budget requirements are for: 2.5 months of 2-person survey team; 1 month of GIS specialist time; GPS equipment; field travel vehicle; film and other supplies; digital camera; access to computer in Barstow. The project may wish to include some biological expertise on the team, to document the springs' plants and wildlife as well.

Budget and FTEs

--------------------FUNDED-------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
			0	
	Total:			

-------------------UNFUNDED------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			35	
Year 2				
	Grand Total:		35	

Project Statement 2. Park Priority 2 of 6

Title: A Coordinated Plan for Development of Ground-Water Monitoring and a Water Source Network for the Mojave NP

Funding Status: Funded: Unfunded: $90K

Problem Statement

This Project Statement proposes two objectives which dovetail, namely: (i) the development of a water monitoring program; and (ii) development of a plan for the management of wells and springs to be obtained during ranchland acquisition.

Rationale: The Mojave National Preserve needs a monitoring program to: (i) gather basic information on its important ground-water resources, (ii) provide data for natural resource management, (iii) evaluate future environmental impacts, and (iv) evaluate the effect of management actions, in and near the Preserve.

The Preserve's *Water Resources Scoping* effort in 1998-99 found that the ground-water data available for the Preserve is only fair to poor in coverage, generally outdated, and for the most part lacking in replicate measurements. Only limited information exists on the depths to water tables, the yields of wells, or the quality of ground-water, and the information is typically 15-plus years old.

Springs are highly significant in the Mojave NP, and serve as a key water source for wildlife, since the area has so few permanent streams or lakes. Information on springs is poor. For example, fewer than a quarter of the springs in the Preserve have any yield data --often only a single measurement from two decades or more ago.

The Preserve is in the process of acquiring substantial ranchland inholdings (with support of a trust organization). The Preserve could gain as many as 13 wells and the water rights for up to 71 springs throughout the entire Preserve area.

This Project Statement proposes the development of a monitoring program at the Preserve, to be founded on the wells and springs to be obtained during the acquisition of water rights related to the land acquisition. Wells and springs presently owned by the NPS also should be included in the monitoring design. This will make possible a monitoring program which is both technically sound and cost effective.

At the same time, the Preserve needs to plan management of the large number of wells. Presumably some wells will be retained for use, while others may be closed. Deciding which wells to use for a monitoring network can be integral to the process of planning the fate of the wells.

Over the decades, the monitoring will provide a highly valuable, essential data set, on which to:

- judge future land-use and water-use impacts on springs and ground water,
- observe drought effects and seasonal changes, or to

- have a key indicator of long-term climate changes.

Description of Recommended Project or Activity

The project has two goals: (i) decide on the fate and management of the operating ranch wells, developed springs, windmills, water pipelines, and other water features obtained with the land acquisition, and (ii) use some of the wells and springs acquired and already owned as a foundation for a ground-water monitoring program.

The new network of wells and springs presents a rare opportunity to build a park ground-water monitoring program at a reasonable cost (compared to $10,000 plus per well it could cost to develop such a network from point zero).

The tasks necessary to accomplish both objectives include:

- survey exactly the locations of the various wells, springs, pipes, tanks, etc;
- determine the construction methods used for wells, to understand depths, casing materials, pump types, and other features;
- develop a plan to close off and seal certain wells, as per state requirements for abandoned wells;
- retain a small, carefully designed network of wells for ground-water monitoring purposes –some for water levels, some water quality, some both;
- develop a plan to use some of the best wells/pipelines for visitors, ranger stations, fire stations, or other supplies, including a general maintenance plan;
- decide which springs or windmills/wells/pipes are most valuable for wildlife;
- determine which wells will be useful for conducting tests of aquifer properties (i.e., transmissivity, storativity, etc);
- decide which springs will be useful for monitoring spring yields.

Four basic types of expertise must be drawn on for the project: (i) surveying; (ii) engineering, (iii) ground-water science, and (iv) biology.

This project will provide an exceptional opportunity to gain insight into the ground water of a major area in the Mojave Desert. Therefore, it is anticipated that U.S. Geological Survey ground-water specialists will want some type of participation, if not the lead. Attempts also should be made to secure matching contributions from them, at least in terms of in-kind expertise. The Preserve can provide biological expertise for the wildlife/water aspects.

The project also should provide per diem costs for a few scientists to take part in a 'brain-storming' meeting at a point early in the project. The USGS also will be strongly encouraged to use the network for research on ground water (ties also to *Project Statement No. 5,* proposing a workshop).

The well monitoring must be designed to allow for measurement of water depths and other observations at the well head, and certain wells will be identified for other measurements (e.g., pump tests). The spring flow measurements would involve simple field observations, using calibrated bucket type devices, and seasonal staff. Volunteers or part-time Preserve staff could play a role in the spring discharge data collection (perhaps tied to other ongoing field surveys).

The project proposed also should include a small training component, to teach the Preserve Natural Resource Specialist how to monitor ground water at wells, take samples, and survey springs. A small manual and data forms would be prepared, for use when monitoring.

Development of the initial monitoring also would include some measurements, including: depths to ground water; water quality samples for basic inorganic chemistry; organic chemistry at a few selected sites; and discharge measurements of springs. Much of the work would be finalized the first year; however, testing may require some adjustment of sites. Some scientist time in the second year would allow for any modifications. Quality assurance and control must be built into the design, to specify the analytical methods, sampling procedures, detection limits, and quality control methodologies.

Budget requirements basically are for: scientist salaries; technical salaries; water quality samples; field measurement equipment; travel; scoping workshop (travel/per diem); and supplies.

Budget and FTEs

--------------------FUNDED-------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
			90	
	Total:			

-------------------UNFUNDED------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			60	
Year 2			30	
	Grand Total:		90	

Project Statement 3. Park Priority 3 of 6

Title: Evaluate the Impact of Nearby Commercial Development on Mojave NP's Ground Water and Springs

Funding Status: Funded: 0 Unfunded: $25K

Problem Statement

Development projects have secured water rights for heavy ground-water pumping near the Mojave National Preserve's boundary, presenting potential for possible impacts on the springs or ground-water tables within the Preserve. (i) The *Primm* project is extracting large volumes of ground water for irrigating a golf course near the northeastern edge of the Preserve, near the town of Primm, NV. (ii) The *Cadiz* project, in a basin near the southern edge of the Preserve, is planned for the near future. This latter project plans to pump up to 20,000 acre feet of ground water annually for export to Southern California's metropolitan area. The project should have an environmental review in the near future. (iii) *Castle Mountain Mining Project's* expansion and water use could potentially affect the water yield of Piute Spring.

The Mojave National Preserve's ground water and springs could be affected by these development projects. The NPS may need to work with the State, EPA, or others to raise objections or to seek certain constraints, if a problem exists. However, at this time, not enough is known to assess the potential impacts or to understand how these projects may affect (or not affect) the Preserve.

The Preserve has no ground-water hydrologist or other water specialist available, and must have some assistance in order to assess the possible hydrologic effects of these projects on the Preserve's ground water and springs. Necessarily the Preserve staff would need to work closely with the Water Resources Division (WRD) of the NPS, especially for expertise on ground-water analyses and water rights. WRD also could help Preserve staff define this project with adequate focus (if necessary, narrowing down, perhaps focusing on one basin) so that the goals are attainable.

The project proposed here would provide the essential technical assistance to the Preserve managers.

Description of Recommended Project or Activity

In order to begin to assess the possible hydrologic effects of these projects on the Preserve's ground water and springs, steps will include:

- Determine the volume of water which is legally allocated to the projects and to other users in the basin studied (also outside Preserve). What allocations have been made? What is the possible effect of the project on the Preserve's water rights, if any?
- Then summarize the total volumes that can legally be extracted in the basin or each basin studied (according to water rights granted and including estimates of other users such as small mines).
- Compare predicted extractions to a best possible estimate of ground-water

recharge for the basin(s) studied, to have an input/output water budget as a first snapshot of whether or not the pumping is sustainable[6].

- Study the existing models and plans of the development or mining projects. (For example, the Cadiz project has used several models and made sophisticated projections, with information available in several reports). The Cadiz project's chief hydrologist is receptive to providing information. The Primm project was presumably handled by a consulting firm, and information would need to be collected.
- After reviewing all of the above and studying the models, work with ground-water scientists and geologists in the USGS as well as the County and State offices, to determine their interpretations.
- Provide the Preserve assistance with a technical review of the Environmental Impact Statement expected for the Cadiz project (which overlaps with some of the above points).
- Advise the Preserve on (i) the potential impacts of these projects or (ii) the need for additional research to evaluate the potential impacts.

The budget would include: salary of the principal investigator (PI), an arid-zone ground-water specialist; consultant fees for one short-term adviser on specific questions (e.g., well engineer or modeling specialist); travel/per diem to San Diego, the Los Angeles area; the Mojave area, and Las Vegas, to discuss findings with local experts; travel to Barstow or other sites to take part in meetings related to the environmental review; telephone/fax/mail expenses; possible university overhead. Other than the travel times, much of the work can be handled out of the PI's home office.

Budget and FTEs

		--------------------FUNDED-------------------		
Source	Activity	Fund Type	Budget ($1K)	FTEs
			25	
	Total:			

		-------------------UNFUNDED------------------		
Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			25	
Year 2				
	Grand Total:		25	

[6] It would be necessary to work with the USGS, State, mining companies, and others to attain all information available on ground-water levels in the area.

Project Statement 4. Park Priority 4 of 6

Title: Assess the Monitoring and Impacts of Mining Activities Affecting the Mojave NP

Funding Status: Funded: 0 Unfunded: 11.0

Problem Statement

This Project Statement proposes short-term, specialized technical assistance to the Mojave National Preserve, to make it possible to evaluate the potential impacts of nearby open-pit mining on the Preserve's springs, ground-water table, and water quality at this time. Such impacts on the Preserve's water resources could have a serious cumulative effect, since in the arid Preserve, springs are the essential water source for wildlife, including some endangered species.

The Preserve has used part-time or short-term persons to assist in these interpretations at critical points until this time, but has no staff person qualified in geohydrology or ground-water contamination[7] to work on these specialized problems.

The Molycorp Incorporated mining operation is the most evident and largest-scale environmental concern in the area. These mining activities occur in the mountains near the northeastern boundary of the Preserve, with waste disposal extending into a valley along the Preserve's eastern boundary. The open-pit mine extracts lanthanides (bastnasite ore), with about 2,000 tons of ore are mined daily. Over 90 percent of the ore is rejected in a slurry and pumped to a tailings pond, which is piped across one corner of the Preserve. Pipe breaks have occurred periodically.

The mining could potentially impact ground-water levels and ground-water quality in the Preserve, given the close proximity of these operations. Ground-water tables in the vicinity of one of the mine's well fields near the Preserve have declined about 100 feet since pumping began in the early 1950s, indicating that aquifer recharge is not keeping up with the withdrawals (ENSR, 1996). These drawdown curves could extend outward, and potentially affect spring flows and well water tables inside the Preserve. Several aspects of the mining operation handle or store pollutants, including:

- The mining area, and the associated tailings pond.
- Storage ponds (mining products are stored in three lined ponds).
- Overburden stockpiles and crushed ore pads.
- Evaporation ponds(principal one about 115 acres in size).
- A 14-mile pipeline to the evaporation pond.

Expansion of the mine site also is proposed, to: enlarge the surface area and depth of the main pit; enlarge the existing tailings pond; construct a new tailings storage impoundment; and construct a new borrow pit. These activities could lead to additional water resource impacts.

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[7] Ms Heather Davies, as of 11-98 with the Department of the Interior, Washington, DC, has assisted periodically with technical reviews and advice.

Consulting firms have prepared a number of large, technical, detailed monitoring plans and water quality models (many of these in response to the Cleanup and Abatement Orders served on the company related to pipeline spills in recent years). In addition, the company has requested additional monitoring and well installation sites to be located on NPS land, inside the Preserve (Molycorp, 1998).

The Preserve needs specialized technical assistance in order to assess the possible hydrologic and water quality effects of the mining operations on the Preserve. The job at hand would require several weeks, but perhaps could be supplementary to a “technical assistance request” to the Water Resource Division staff in Fort Collins.

Description of Recommended Project or Activity

In view of the problem described above, short-term, specialized technical assistance is needed at the Preserve, to:

- assess the mining company plans and models;
- visit the mine facilities on the ground;
- discuss the specifics of the plans and models with the water quality and ground-water specialists in the state Water Quality Control Board office in Victorville, the environmental specialist at BLM in Needles, the County (San Bernardino) geologist; and
- conduct the necessary technical analyses of the models, appraising the calculations, assumptions, extrapolations, and other details.

The short-term consultant would determine if the sampling parameters and frequency of sampling planned by the company are adequate and appropriate to answer the questions of potential impacts on the Preserve. He/she would evaluate the models for their potential value in predicting water-quality and ground-water impacts on the Preserve (or not), and make interpretation as to possible impacts on the Preserve.

The budget will need to cover:
- salary of the principal consultant for 4 weeks spread over 4 months --to allow time for response to inquiries, the scheduling of meetings, review turnarounds, etc (a ground-water/water-quality specialist; competent in models and monitoring; 10+ years experience; possibly MS level education or equivalent);
- travel/per diem to the Mojave, Los Angeles, and Las Vegas areas to discuss findings with relevant experts;
- per diem for the Preserve area (~ 3 weeks @ $110/day)
- 5 days salary to bring on secondary, local consultant for advice on <u>local</u> geology;
- field travel in the Barstow area;
- telephone/fax/mail expenses; possible university overhead. Other than the travel times.

About two weeks of the work would be in the Preserve area. The other 2 weeks could be at the consultant’s home office.

Budget and FTEs

--------------------FUNDED-------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
			11.0	
	Total:			

-------------------UNFUNDED------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			11.0	
Year 2				
	Grand Total:		11.0	

Project Statement 5. Park Priority 6 of 6

Title: A Workshop on Water Resources and Ground-Water Impacts in the Mojave National Preserve

Funding Status: Funded: 0 Unfunded: $11K

Problem Statement

This Project Statement proposes a workshop at the Mojave National Preserve to:

- Introduce ground-water specialists and hydrologic scientists to the water issues which exist in the Preserve area, to stimulate their interest, and to gain their cooperation on issues;
- Provide a platform for Preserve managers to meet with the geohydrologists and other specialists, to gain advice on a water resource program for the Preserve;
- Interest scientists in the excellent opportunities for research in ground-water and arid-zone hydrology in the Preserve; and
- Develop a list of water-related research needs for the Preserve.

The Mojave National Preserve has a large number of water issues at hand, including: the impact of mine pollution; the effects on ground water of heavy well pumping for nearby development, flash flood hazards, pipeline spills, water rights concerns, how to manage water for wildlife, exotic vegetation impacts on seep areas, and the need for essential hydrologic data for the area.

The vast, 1.6 million acre Preserve provides an good representation of the Mojave Desert ecosystems, watersheds, and closed basins, with mountains at over 7,000 feet and playas at 1,000 feet, with a great complexity of geology. It offers exceptional opportunities for arid-zone hydrology research.

A basic problem in dealing with water-related issues in the Preserve is a lack of hydrologic knowledge for the area. Although detailed and sophisticated ground-water research has occurred in the western Mojave Desert, knowledge of ground water and its characteristics and processes in the Preserve area is limited. Practically no hydrologic research has occurred in the Preserve in the past 20 years. Interpretation of recharge in the area, for example, is based on the hypotheses of a few geologists decades ago, drawing on very limited measurements and casual observations. Monitoring was basically eliminated from the area in the early 80s, so only limited ground-water data exists from recent decades. No recharge studies per se have occurred.

An understanding of ground water is needed to evaluate the major proposals for ground-water extraction now at hand and to evaluate when ground water would be “mined” and when it would be used sustainably.

A workshop would serve as the springboard to stimulate interest in ground-water research in the Preserve, and provide a forum to encourage the U.S. Geological Survey, university departments, and other organizations to consider cooperative research on ground-water in the basins of the Preserve.

The workshop also could present an opportunity to develop a small, continuing advisory committee to advise the Preserve on its water resource program.

Description of Recommended Project or Activity

Conduct a 2.5 day workshop at the Mojave National Preserve on geohydrology and water issues. Participants would include water specialists from at least:

- U.S. Geological Survey (San Diego and Palo Alto);
- Regional Water Quality Control Board (two regions involved);
- County of San Bernardino (Geology and Planning groups);
- 2-4 key university specialists from CA and NV;
- NPS Water Resources Division, Fort Collins/Denver;
- 1-2 other National Park units with similar problems and needs.

The workshop would include: (i) presentations on topics which fit the theme, (ii) a day's field tour to see select issues and Preserve features on the ground (and discuss on site); (iii) brainstorming for recommendations. The wrap-up discussions and abstracts of the presentations would be summarized in a brief proceedings.

Budget costs would include: travel/per diem for the U.S. government agency participants; one week of consultant time, to develop agenda, make invitations, and prepare materials (handouts, etc); local meeting room rental, with projectors, flip charts, etc; van rental for the field tour.

Budget and FTEs

		--------------------FUNDED-------------------		
Source	Activity	Fund Type	Budget ($1K)	FTEs
			11	
	Total:			

		-------------------UNFUNDED------------------		
Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			11	
Year 2				
	Grand Total:		11	

Project Statement 6. Park Priority 5 of 6

Title: Develop Recommendations for Reclamation of Abandoned Mine Areas in the Mojave NP

Funding Status: Funded: Unfunded: $20K

Problem Statement

Many abandoned mines have been left in the Mojave National Preserve, leaving deep open pits, eroded hillsides, tailings, dumps, old ponds, or other scars or debris at many sites on the landscape. This Project Statement proposes a survey of these abandoned mines to determine which sites should be candidates for reclamation. Note: This Project Statement would provide for an initial overview of general technical design options, recognizing that detailed design work, for individual projects, would require additional funding.

Abandoned mines can produce many environmental problems. Old leach pads, dumps, or other features can continue to seep pollutants, such as cyanide, which can contaminate the area or the ground water. Closed contaminated ponds can be a hazard to birds. Some eroded areas can be aesthetically undesirable or produce sediment. Deep pits with water may be an attractive nuisance.

Description of Recommended Project or Activity

Technical assistance is needed to conduct field surveys to:

- Develop criteria to rate the abandoned mine sites in terms of their environmental or safety hazards.
- Develop physical/biological criteria for determining suitability of sites for reclamation --working with the Preserve geologist and other staff to develop these criteria.
- Develop economic criteria for determine sites where reclamation is financially feasible.
- Conduct field surveys of sites, including sampling of soils and water. Review any existing information on the sites (e.g., water pollution data, photographs, etc) to evaluate the open pits, eroded sites, and other features. Rate each site by the criteria that were developed.
- Screen sites with the criteria to determine which ones would be financially and physically feasible for reclamation.
- Working with the Preserve geologist and natural resource specialists, review the survey findings and criteria determinations and prioritize the sites which are feasible for reclamation.

For the sites with highest priority for reclamation:

(1) develop a technical design for the reclamation at a broad-brush level;
(2) cost out each possible project in broad terms.

This project would lay the groundwork to identify potential projects and approximate costs. Additional design work could then follow up for individual sites of interest, to prepare engineering designs and cost details at a level needed to carry out the reclamation work.

The budget would include a principal investigator and technical field assistant for 4 weeks in the field, 2 in the office, with per diem, field survey equipment (some available at the Preserve), supplies.

Budget and FTEs

--------------------FUNDED-------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
	Total:			

-------------------UNFUNDED------------------

Source	Activity	Fund Type	Budget ($1K)	FTEs
Year 1			20.0	
Grand Total			20.0	

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7. DIRECTORY OF ORGANIZATIONS AND EXPERTISE

Legend for the Directory
1. JONES: ALL CAPS NAME = persons MET while assembling this report (by Kunkle, Reetz, or Hagemann)
2. Jones : underlined name = persons contacted by telephone or correspondence in preparing the report
3. Jones: = other important names mentioned as involved in water resources (not contacted)

Baker Community Services District	Lee Hayes (Public service group for water & wastewater).
Bilhorn, Tom Escondido, CA	TOM BILHORN (619) 485-6457, assisted on questions of tamarisk, etc tbilhorn@inetworld.net
Bureau of Land Management (BLM), Barstow Field Office	ANTHONY CHAVEZ (760) 252-6036, Rangeland Manager rchavez@ca.blm.gov Tom Egan (760) 252-6032, tegan@ca.blm.gov Ken Schulte, geologist, mining topics. Larry Monroe (geologist), mining topics.
BLM (Needles Field Office) BLM 101 West Spikes Road Needles, CA 92363	GARY SHARPE (760) 326-7020, Resources Chief. BILL WILEY, (760) 326-7002, Environmental Protection Specialist, involved in spills, impacts. KEN DOWNING (760) 326-7017, Geologist, kdowning@ca.bllm.gov. Willow Yumico (760) 326-7000, has worked on tamarisk questions in BLM areas. MOLLY BRADY (760) 326-7000/7014, Manager. Mike McGill (760) 326-7000, wildlife manager. George Micksessell, environmental impacts role. Leslie Smith, recreation planner.
BLM (District Office) BLM, 6221 Box Springs Blvd, Riverside 92507	ROB WAIWOOD (909) 697-5306, team leader & geologist. LARRY MORGAN (909) 697-5388, range conservationist and watershed specialist. Larry Foreman (909) 697-5387, wildlife biologist, knows MOJA springs, guzzlers. Tom Zmudka (909) 697-5239, GIS specialist, spring/guzzler “WHIP” map info and data person. DOUGLAS ROMOLI (provided water diversions list)
BLM Denver	Paul Summers (303) 236-0151,(looked at ground water in the area about 1995).
BLM State Office, Sacramento	Rob Nauert (916) 978-4647, water rights specialist.
Biological Research Division (BRD) of the USGS	see USGS, BRD

Broadbent & Assoc Inc 833 Nevada Highway Suite 4 Boulder City, NV 89005	SCOTT MCNULTY (702) 563-0600, Project Geologist (8 West Pacific Ave., Henderson, NV, 89015; fax 702-563-0610; smcnulty@broadbentinc.com). Field monitoring, Piute. Robert Broadbent (702) 293-6070, coordinating Viceroy Gold Corp's monitoring at Piute Spring. Ground water modeling.
Bureau of Reclamation Reclamation Service Center; P.O. Box 25007; Building 67; DFC; Denver, CO 80225-0007	Chris Danley, P.E. Reviewed maps of MOJA to determine "no water control structures" relevant to BuRec (not a field inspection)
Cadiz Land Co, Inc P.O. Box 535, Cadiz, CA 92319 Mark A. Liggett; Cadiz Inc. Land Co; 1701 Clinton St; Suite 212; Los Angeles, CA 90026.	In Los Angeles: Mark A. Liggett (213) 483-5127, Senior VP, Hydrology, fax (213) 483-5746, key designer of the project. In Cadiz: Lesley E. Benjamin, Sun World International, Inc Also Cadiz Land Co Inc, 100 Wilshire Blvd, Suite 1600, Santa Monica, CA 90401
California Dept of Toxic Substances Control Glendale	Florence Gharibian (818) 551-2925, hazardous materials, radioactive substances.
California Desert Studies Consortium	see DESERT STUDIES CENTER, Baker
California State Water Resources Control Board; Division of Water Rights; P.O. Box 2000; Sacramento, CA 95812-2000	General # (916) 657-1350 and (916) 657-2000 Ken Beyer (916) 657-2215; engineer for surface water rights.
California Dept of Fish & Game 21091 Sioux Road; Apple Valley, CA 92308 (Al Lapp, 109429 Highway 395, Coleville, CA 96107).	Andy Pauli (760) 240-1372, knows guzzlers well in MOJA area. Al Lapp (916) 495-2570 , Wildlife Habitat Supervisor, head of "guzzler crew" for southern CA, Coleville (local guzzler crew is at Camp Cady).
California (Lahontan) Regional Water Quality Control Board, Lahontan Region, Victorville 15428 Civic Drive; Suite 100; Victorville, CA 92392	CINDI MITTON (760) 241-6583, Senior Engineer cmitton@rb6v.swrcb.ca.gov ELIZABETH LAFFERTY (760) 241-7358, Assc Engineering Geologist; (toxics unit), mining impacts elaffert@rb6v.swrcb.ca.gov CURT SHIFRER, PE (760) 241-6583 cshifrer@rb6v.swrcb.ca.gov

	CHRIS MAXWELL (760) 241-7412 geologist (permitting unit) hazmat, mining impacts. Ken Carter (760) 241-7412, Senior Engineer/supervisor fax: (760) 241-7308 [Receptionist: (760) 241-6583]. Re: their Tahoe office: Judy Undsicker, handling basin planning.
California (Colorado River Basin) Regional Water Quality Conrol Board; Calif. Regional Water Quality Control Board; 73-720 Fred Waring Dr; Suite 100; Palm Desert, CA 92260	Robert Perdue (760) 776-8945, Coordinator, Senior Geological Engineer (re: Castle Mt, Viceroy) & other mining in the Providence/NY range. Rob Tucker (760) 776-8945; Water Resources Control Engineer (now in their Tahoe office, but knows the Providence/NY range area)).
California Dept of Water Resources Glendale	Feroze Kanga (818) 543-4600 x225 5/98 provided ground-water readings (on Excel list) re: Gary Gilberath (818) 543-4600 x222 Ed Low (818) 543-4600 x223; general long experience in the state Krista Klasson (818) 543-4600 x 232 Water pubs & info.
California (Drinking Water)	Jesse Dhaliwal (909) 383-4312, drinking water systems with multiple connections, e.g., Death Valley, Furnace Creek (not MOJA). Kal Baliga (909) 383-4312, supervisor
California (Other)	Frank Hoover (909) 597-8235 (fisheries), knows guzzlers, Chino, CA. Dinah Shumway, Ca Div of Mines & Geology, on campus at Riverside (with Doug Morton).
Casebier, Dennis MOJA area	Dennis Casebier (760) 733-4482, historian in area; various books on mining history & 'jeeping,' in the area.
Castle Mountain Mine	See Viceroy Gold
Corps of Engineers	see USACOE
Dept of Defense	see Military
Dept of Interior USGS; Placer Hall; Suite 2012; 6000 J. Street; Sacramento, CA; 95819-6129	(916) 278-3026; DOI Coordinator, Mojave Desert Groups with DOI agencies and the military. Heather Davies (see NPS, other)
Desert Studies Center	Robert E. Fulton, (760) 733-4266; Manager (in Baker), with library there. William Presch (714) 278-2428, Fullerton, Cal State University P.O. Box 490, Baker, CA. 92309

Dynamac Corp 2275 Research Blvd Suite 500 Rockville, Md. 20850	Robert Dover (301) 417-6089, was project manager on Molycorp's sampling report, July 98.
Environmental Protection Agency (U.S.) EPA, Region 9 75 Hawthorne St San Francisco, CA 94105	John Hillenbrand (415) 744-1912, Geologist, Water Division
Granite Mountain Natural Reserve (University of CA) Kelso	Jim Andre' (760) 733-4222 Claudia Luke (760) 733-4222 (Kathryn Thomas, BRD now, has had vegetation role)
MILITARY Clarence Everly, Mojave Desert Ecosystem Program, P.O. Box 105097, Ft Irwin, CA, 92310	CLARENCE EVERLY (760) 380-5291, Ft Irwin Coordinator for the Mojave Desert Ecosystem Program. http://mojave.army.mil CHRISTINE MCALLISTER (GIS specialist) Micky Quillman (760) 380-3433 , Ft Irwin (biologist). Phil Miller (760) 830-7516, Director of Nat. Res., 29 Palms (Marines). Art Gleason (760) 577-6111, Hazmat & WQ person, Marines, Barstow.oing veg work in area this year)
Mojave Desert Ecosystem Program	Len Gaydos (650) 604-6368; San Francisco; Len@usgs.gov (doing Mojave survey with the MDEP http://geology.wr.usgs.gov/MojaveEco (but not related to water at this time) Richard Barber (see DOI) Peter Stine (916) 278-3251 or (530) 754-2122 in Sacramento & Davis, USGS, BRD (Chairman of the Science & Data Mgt Team for the MDEP) Hank McCutcheon, at Joshua Tree (NPS contact on the Mojave Desert Ecosystem Program)
Mojave Water Agency 25450 Headquarters Rd P.O. Box 1089 Apple Valley, CA 92307	Larry Rowe (760) 240-9201 lead person for MWA NORM CAOUETTE (has a library with general info on the broader Mojave area) MONICA WARREN (760) 240-9201 (handles library)
MOLYCORP Molycorp Inc. P.O. Box 124 (67750 Bailey Road), Mountain Pass, CA 92366	(also see Dynamac and) John A. Vialpando, Tech Services Mgr (760) 856-2201 fax (760) 856-2253

Nipton	Jerry Freeman (bottles water there)
NPS, Mojave NP, Barstow 222 E. Main St., Suite 202, Barstow, CA 92311	(principal contacts) MARY MARTIN (760) 255-8803 (Superintendent). GORDON REETZ, 255-8849, Natural Resources Specialist. JEAN DE LOS REYES 255-8841, GIS. MIKE REYNOLDS, Chief, Special Uses DENNIS SCHRAMM 255-8840, Team Leader, Planning. TONY GROSS 255-8865, environmental compliance. ANDY LESZCYKOWSKI 255-8804, geology. CHRIS STUBBS 255-8815, natural resources. DAVID MOORE 255-8850, water supply. CAROL CROSBY (FWS) 255-8845. DAVE ANDERSON (new hazmat person fall, '98)
NPS, Mojave NP, Needles Office Needles Info Center 707 W. Broadway Needles, CA 92363-2910	JAMES WOOLSEY (760) 326-6322, visitor use. Welford Garner, visitor use. fax: (760) 326-4119
NPS, Water Resources Division, Fort Collins & Denver	MATT HAGEMANN (970) 225-3535, Geohydrologist and hazmat person. DAN MCGLOTHLIN (970) 225-3536, principal WRD contact, water rights. CHUCK PETTEE (970) 225-3505, Branch Chief, Water Rights. MIKE MARTIN, GARY SMILLIE (970) 225-3522, engineers/hydrologists on Kelso floodplain issue. MARK FLORA (303) 969-2956 WRD, Planning & Evaluation Branch and DAVID VANA-MILLER (303) 969-2813 WRD, P&E Branch.
NPS, Other and U.S. Department of the Interior	Heather Davis (703) 569-9351, Wash, DC, Dept of Interior as of 11/98 (was involved in Molycorp issues part time). Peter Rowlands (520) 387-7662 Organ Pipe NM, AZ (transferred there from BRD in 5/98). Did extensive vegetative work in MOJA area (several reports). Mark Ziegenbein (303) 969-2957, Geologic Resources Division, Denver (visited mines in the area)

	HANK MCCUTCHEON, at Joshua Tree (NPS contact on Mojave Desert Ecosystem Program)
Nevada	See Southern Nevada Water Authority
Ranchers, local	HOWARD BLAIR; ROB BLAIR. CLAY OVERSON (O-X Ranch).
SAN BERNARDINO COUNTY San Bernardino	WES REEDER, (909) 387-4222, County Geologist wreeder@co.san-bernardino.ca.us RICH TOUSLEE (see also under Victorville) DICK HORNBY & SCOTT ROSE (909) 387-4666 & 884-4056, well permits, water sanitation. Tony Gray (909) 387-2727, designer, flood projects. Randy Scott (909) 387-4146, Senior Planner. Michael Fox (909) 387-2515, Chief of the Water Res. Div. Ken Guidry (909) 387-2525, Chief of Flood Control Div.
San Bernardino County, Redlands Museum 2024 Orange Tree Lane, Redlands, CA 92374	BOB REYNOLDS, (909) 798-8570 x 233, Curator, Earth Sciences (paleontology) ROBERT L. MCKERNAN, (909) 307-2669 x 232, Curator, Biology.
San Bernardino County, Victorville Office	MIKE WILLIAMS, (760) 243-8225 Planning. RICH TOUSLEE (760) 243-8175 Victorville and (909) 387-4105 San Bernardino, involvement, mines in the area. DICK THOMPSON, transportation department.
San Bernardino Fire Dept	Pete Brierty, (?909) 387-3200, re: toxic spills, hazmat.
Sheep Society (Society for the Conservation of the Big Horn Sheep)	R.S. Campbell Updating Sheep Society map of springs/guzzlers in the broader Mojave area. 1725 Snughaven Ct; Las Vegas, NV, 89108
Southern Nevada Water Authority 1001 South Valley View Blvd, Las Vegas, NV 89153	Bill Quinn (702) 259-8181, Hydrologist, george.quinn@lvvwd.com
Sun World Intern'l Inc	see Cadiz
USACOE	Everly mentioned: Bob Koenigs (916) 557-6712 ("task person on the geologic data, in Sacramento) mentioned also: Joe Watts, Topographic Engineering Center; veg maps for MDEI. Antal Szijj (909) 478-5500 Redlands
US EPA	see EPA
US Fish and Wildlife Service	CAROL CROSBY (760) 255-8845, stationed at Preserve.

USGS BRD	Don Ebert (702) 895-3732; BRD, Las Vegas, now with EPA. Kathryn Thomas (520) 556-7466; fax (520) 556-7500; BRD; Flagstaff; doing vegetative work for Mojave area ("Mojave Desert Vegetation Mapping Team"). Kat@usgs.nau.edu P.O. Box 5614; Flagstaff, AZ; 86011. Jim Thorn (520) 556-7466 x225, vegetation specialist, Jim_Thorne@usgs.gov Jim Thorne; Colorado Plateau Field Station; NAU; Box 5614; Building 24; Flagstaff, AZ. 86011-5614 Hal Avery (909) 787-4286 in Riverside. Peter Stine (see Mojave Desert Groups) Julie Evans, Humboldt State student looking at vegetation for Granite Mt people in summer 98
USGS, San Diego 5735 Kearny Villa Road, Suite O, San Diego, CA 92123 fax for all (619) 637-9201	PETER MARTIN (619) 637-6827, team leader. JILL DENSMORE-JUDY, (619) 637-6842, Hydrologist. JERRY WOODCOX, (619) 637-6862, Technical Editor. JULIA HUFF (619) 637-6823, ground-water data, jahuff@usgs.gov CHRISTINA STAMOS (619) 637-6841, model development (upper Mojave) clstamos@usgs.gov John Izbicki, studies in East Mojave. Greg Lines (619) 637-6857 vegetation. ALLEN CHRISTENSEN, Hydrologist, (619) 637-6875
USGS Sacramento USGS Placer Hall 6000 J Street Sacramento, CA 95819-6129	Charlie Alpers (916) 278-3134, project chief on assessment of the Molycorp mining at Mountain Pass, cnalpers@usgs.gov
USGS Other	Terry Rees (702) 887-7635, Las Vegas, re: Mexico border issues (formerly San Diego). Dave Miller (650) 329-4923, Geologist (Menlo Park), dmiller@isdmnl.wr.usgs.gov (digitized geology map, So.CA, working with Bonnie Murchey (650) 329-5101, Menlo Park, liaison person with NPS on geology. Mike Shulters (650) 329-4002 (District Chief) Len Gaydos (see Mojave Desert) Doug Morton (see U of CA, Riverside)
University of California, Riverside	Doug Morton (909) 276-6397; USGS person at Geology Dept, UCR (digital mapping of Southern Calif with Dave Miller, USGS).
University of California, Granite Mt	(see Granite Mt; also see California Desert Studies Consortium for the other college group)

UNIVERSITY OF NEVADA	Don Ebert see USGS, BRD Dave Kaeamer (702) 895-3553 School of Geology, Water Resources Institute. Klaus Stetzenbach (702) 895-3742; geologist.
Vanderbilt Gold Corp 4625 Wynn Road, Suite 103, Bldg C, Las Vegas, NV 89103	Paul Skinne, Mine Operation Mgr (702) 362-3152
Viceroy Mining	GEORGE BERNATH (702) 252-8040; Environmental Technician (monitoring, reports to CA Palm Desert District)
Werrell, Bill	Bill Werrell (702) 751-3405, engineer, well specialist, former NPS familiar with Mojave NP.

8. APPENDICES

Appendix 1. U.S. Geological Survey's record of water level readings in wells in the Mojave National Preserve (courtesy of the USGS, San Diego office, 1998, personal communication, Julia Huff).

CLARK AREA OF THE PRESERVE

1DATE: 05/12/98 PAGE 1

LOCAL WELL NUMBER	LATITUDE (DEGREES)	LONGITUDE (DEGREES)	WATER-LEVEL DATE (FIRST)	WATER-LEVEL DATE (LAST)	WATER-LEVEL DATE (COUNT)
017N013E15J001S	353329	1153328	10-01-1969	10-01-1969	1
017N013E15J002S	353329	1153328	10-01-1969	10-01-1969	1
017N013E24M001S	353240	1153207	10-01-1969	10-01-1969	1

MAIN AREA OF THE PRESERVE

1DATE: 05/12/98

LOCAL WELL NUMBER	LATITUDE (DEGREES)	LONGITUDE (DEGREES)	WATER-LEVEL DATE (FIRST)	WATER-LEVEL DATE (LAST)	WATER-LEVEL DATE (COUNT)
007N012E01F001S	344340	1154034	08-04-1981	08-04-1981	1
008N013E10E001S	344756	1153642	08-05-1981	08-05-1981	1
008N013E15P001S	344640	1153623	08-05-1981	08-05-1981	1
008N013E18F001S	344706	1153933	08-04-1981	08-04-1981	1
008N014E05N001S	344822	1153236	08-05-1981	08-05-1981	1
008N017E02D001S	344931	1151036	12-14-1925	01-07-1982	10
008N017E04E001S	344843	1151235	05-28-1968	07-24-1981	2
009N014E03C001S	345413	1153020	08-06-1981	08-06-1981	1
009N014E03F001S	345410	1153016	08-06-1981	08-06-1981	1
009N014E08R001S	345246	1153144	08-10-1981	08-10-1981	1
010N011E06R001S	345854	1155129	09-23-1965	09-23-1965	1
010N014E22K001S	345632	1153006	07-23-1981	07-23-1981	1
010N014E32G001S	345503	1153202	08-11-1981	08-11-1981	1
010N015E07B001S	345838	1152644	07-23-1981	07-23-1981	1
010N015E29A001S	345606	1152526	11-23-1917	09-02-1981	2
010N015E29A002S	345606	1152524	07-22-1981	07-22-1981	1
010N015E29A003S	345606	1152542	08-12-1981	08-12-1981	1
011N012E25G002S	350040	1153857	07-19-1978	03-22-1984	6
011N014E33N001S	345904	1152951	07-23-1981	07-23-1981	1
011N014E35M001S	345915	1152742	07-23-1981	07-23-1981	1
011N015E06C001S	350403	1152446	08-18-1981	08-18-1981	1
011N015E06J001S	350334	1152412	08-18-1981	08-18-1981	1
011N015E08K001S	350246	1152318	05-14-1971	05-14-1971	1
011N015E17M001S	350201	1152352	08-13-1981	08-13-1981	1
011N017E05R001S	350328	1150949	01-21-1953	05-22-1958	2
011N017E05R002S	350328	1150949	09-13-1953	09-01-1981	13
011N017E05R003S	350328	1150953	05-16-1959	09-01-1981	4
011N018E09L001S	350253	1150243	08-02-1978	08-02-1978	1
012N008E11E001S	350834	1160631	03-30-1985	03-30-1985	1

012N008E27N002S	350525	1160739	03-07-1961	10-30-1970	16
012N008E35A001S	350514	1160535	03-07-1961	10-30-1970	8
012N014E24E001S	350642	1152645	08-13-1981	08-13-1981	1
012N014E36R001S	350433	1152554	08-18-1981	08-18-1981	1
012N015E03L001S	350849	1152130	11- -1917	08-29-1981	13
012N015E03M001S	350848	1152153	08-21-1981	08-21-1981	1
012N015E07A001S	350823	1152408	09-02-1981	09-02-1981	1
012N015E08D001S	350823	1152404	09-02-1981	09-02-1981	1
012N015E08D002S	350823	1152404	09-02-1981	09-02-1981	1
012N015E09M001S	350805	1152255	08-29-1981	08-29-1981	1
012N015E09Q001S	350746	1152223	08-29-1981	08-29-1981	1

1DATE: 05/12/98

LOCAL WELL NUMBER	LATITUDE (DEGREES)	LONGITUDE (DEGREES)	WATER-LEVEL DATE (FIRST)	WATER-LEVEL DATE (LAST)	WATER-LEVEL DATE (COUNT)
012N015E11B001S	350824	1152023	08-21-1981	08-21-1981	1
012N015E11G001S	350811	1152007	08-21-1981	08-21-1981	1
012N015E17B001S	350732	1152325	11- -1917	09-02-1981	2
012N015E17B002S	350732	1152325	09-02-1981	09-02-1981	1
012N015E17B003S	350732	1152319	09-02-1981	09-02-1981	1
012N015E17N001S	350657	1152350	08-19-1981	08-19-1981	1
012N015E19H002S	350625	1152422	09-02-1981	09-02-1981	1
012N015E20P001S	350609	1152340	08-19-1981	08-19-1981	1
012N015E20P002S	350557	1152338	08-19-1981	08-19-1981	1
012N015E29C001S	350546	1152348	08-19-1981	08-19-1981	1
012N015E31M001S	350428	1152535	11-22-1917	11-22-1917	1
012N015E33D001S	350451	1152250	08-19-1981	08-19-1981	1
012N016E18L001S	350703	1151810	08-20-1981	08-20-1981	1
012N016E19C002S	350650	1151818	08-20-1981	08-20-1981	1
012N017E04D001S	350923	1150935	- -1937	11-17-1983	7
012N017E04N001S	350844	1150929	08-31-1981	11-17-1983	4
012N017E04P001S	350842	1150920	08-31-1981	08-31-1981	1
012N017E17J001S	350705	1150948	- -1912	07-27-1978	13
012N017E18A001S	350740	1151055	11-01-1981	11-01-1981	1
012N018E30E001S	350540	1150505	08-31-1981	08-31-1981	1
012N018E30E002S	350540	1150505	08-31-1981	08-31-1981	1
013N008E01H001S	351437	1160436	03-08-1961	10-30-1970	15
013N009E20J001S	351148	1160221	02-18-1954	03-22-1984	35
013N014E10R001S	351305	1152750	01-01-1970	01-01-1970	1
013N014E11N001S	351311	1152733	12-01-1969	12-01-1969	1
013N014E11N002S	351317	1152740	01-01-1970	01-01-1970	1
013N014E11N003S	351314	1152731	01-01-1970	01-01-1970	1
013N014E11N004S	351309	1152731	01-01-1970	01-01-1970	1
013N015E02P001S	351357	1152031	08-27-1981	08-27-1981	1
013N015E04E001S	351415	1152249	01-01-1970	01-01-1970	1
013N015E04M001S	351411	1152251	01-01-1970	01-01-1970	1
013N015E09G001S	351322	1152218	08-14-1981	08-14-1981	1
013N015E09H001S	351322	1152212	08-14-1981	08-14-1981	1
013N015E11F001S	351328	1152037	08-27-1981	08-27-1981	1
013N015E11G001S	351327	1152013	08-27-1981	08-27-1981	1
013N015E22D001S	351154	1152200	08-14-1981	08-14-1981	1
013N015E22J001S	351130	1152109	08-14-1981	08-14-1981	1
013N015E34K001S	350940	1152121	08-29-1981	08-29-1981	1
013N015E34M001S	350944	1152155	08-29-1981	08-29-1981	1
013N015E34N001S	350933	1152152	08-29-1981	08-29-1981	1

1DATE: 05/12/98

LOCAL WELL NUMBER	LATITUDE (DEGREES)	LONGITUDE (DEGREES)	WATER-LEVEL DATE (FIRST)	WATER-LEVEL DATE (LAST)	WATER-LEVEL DATE (COUNT)
013N015E36A001S	351003	1151903	08-20-1981	08-20-1981	1
013N015E36A002S	351003	1151903	08-20-1981	08-20-1981	1
013N015E36N001S	350928	1151951	08-20-1981	08-20-1981	1
013N016E07B001S	351332	1151802	05-16-1959	08-20-1981	5
013N017E18N001S	351208	1151203	- -1912	05-17-1982	5
014N013E01K001S	351925	1153229	12-01-1969	12-01-1969	1
014N013E10D001S	351856	1153459	12-01-1969	12-01-1969	1
014N013E11P001S	351827	1153353	- -1927	- -1927	1
014N013E13H001S	351754	1153206	04-16-1953	03-28-1963	3
014N013E13J001S	351750	1153205	12-01-1969	12-01-1969	1
014N013E23R001S	351644	1153316	12-01-1969	12-01-1969	1
014N013E23R002S	351640	1153319	12-01-1969	12-01-1969	1
014N013E23R003S	351640	1153319	12-01-1969	12-01-1969	1
014N013E25M002S	351555	1153256	12-01-1969	12-01-1969	1
014N014E18E002S	351800	1153200	12-01-1969	12-01-1969	1
014N016E02M001S	351922	1151403	01-01-1970	01-01-1970	1
014N016E03D001S	351945	1151518	- -1929	01-09-1970	3
014N016E03E001S	351938	1151510	01-01-1970	01-01-1970	1
014N016E03F001S	351935	1151455	- -1967	- -1967	1
014N016E03F003S	351928	1151454	01-01-1970	01-01-1970	1
014N016E03F004S	351939	1151456	01-01-1970	01-01-1970	1
014N016E03R001S	351903	1151428	01-01-1970	01-01-1970	1
014N016E04C001S	351940	1151456	01-01-1970	01-01-1970	1
014N016E07L001S	351826	1151809	06-25-1968	11-03-1968	2
014N016E09A001S	351858	1151532	05-22-1958	01-09-1970	7
014N016E14K001S	351730	1151338	09-13-1953	05-21-1963	11
014N016E14K002S	351730	1151338	08-26-1981	08-26-1981	1
014N016E14K003S	351730	1151338	06-27-1952	08-26-1981	2
014N016E14M001S	351732	1151414	01-14-1903	08-26-1981	2
014N016E14P001S	351721	1151352	08-26-1981	08-26-1981	1
014N016E14Q001S	351720	1151336	08-26-1981	08-26-1981	1
014N016E15Q001S	351724	1151436	05-22-1958	08-25-1981	7
014N016E17B001S	351802	1151646	- -1927	- -1927	1
014N016E22M001S	351644	1151502	09-13-1953	08-25-1981	14
014N016E22M002S	351644	1151502	08-25-1981	08-25-1981	1
014N016E28J001S	351548	1151534	08-25-1981	08-25-1981	1
015N012E16H001S	352316	1154207	07-20-1978	05-19-1982	4
015N012E16H002S	352308	1154206	04-17-1979	11-17-1982	5
015N014E22E001S	352219	1152848	11-01-1969	11-01-1969	1
015N014E28C002S	352137	1152926	11-01-1969	11-07-1969	2

1DATE: 05/12/98

LOCAL WELL NUMBER	LATITUDE (DEGREES)	LONGITUDE (DEGREES)	WATER-LEVEL DATE (FIRST)	WATER-LEVEL DATE (LAST)	WATER-LEVEL DATE (COUNT)
015N014E33C001S	352045	1152937	11-01-1969	11-01-1969	1
015N015E13G001S	352308	1151939	08-30-1905	10- -1917	2
015N015E13G002S	352306	1151939	05-15-1923	11-17-1982	8
015N015E13G003S	352306	1151939	10-21-1944	03-14-1967	15
015N015E57L001S	352720	1152231	- -1916	05-15-1959	2

015N015E59N001S	352713	1152044	- -1916	04-19-1984	23
015N015E59P001S	352716	1152029	05-15-1959	05-15-1959	1
015N016E33R001S	352008	1151613	01-01-1970	01-01-1970	1
015N016E33R002S	352008	1151613	01-01-1970	01-01-1970	1
015N016E33R003S	352002	1151619	01-01-1970	01-01-1970	1
015N016E33R004S	352002	1151619	01-01-1970	01-01-1970	1
015N016E33R005S	352006	1151612	01-01-1970	01-01-1970	1
015N016E34L001S	352025	1151549	01-01-1970	01-01-1970	1
015N017E08H001S	352356	1150947	11-01-1969	11-01-1969	1
015N017E26Q001S	352051	1150655	07-31-1958	07-31-1958	1
016N012E26N001S	352626	1154023	11-17-1956	04-19-1984	20

Appendix 2. A list of water rights registered for the Mojave NP area, from the California Water Resources Control Board, Division of Water Rights, Sacramento, as of 1998 (see footnote for definition of **).

APPL. NUM.	T		R	SEC	1/4	¼	SOURCE	TRIBUTARY	OWNER NAME	D/D AMT	D/DU	STO AMT	USE
S013296	8	N	12	3	SW	NE	SHEEPHORN SPRING	BULL CANYON	OVERSON, CLAY	375.00	G	0.00	S
S013297	8	N	12	10	NE	NE	BULL CANYON SPRING	DEVILS PLAYGROUND WASH	OVERSON, SANDRA	525.00	G	0.00	S
S013298	8	N	12	12	NE	NW	COTTONWOOD SPRING	COTTONWOOD WASH	OVERSON, CLAY	750.00	G	0.00	S
S009124	8	N	12	15	SW	NE	SIDEDRAW SPRING	WILLOW SPRING WASH	U.S. BUREAU OF LAND MGMT	360.00	G	0.00	W
S013299	8	N	12	20	NW	NE	BUDWEISER SPRING	BUDWEISER WASH	OVERSON, CLAY	1500.00	G	0.00	S
F007888S	8	N	12	22	NE	NE	BASALT SPRING	UNST	U.S. BUREAU OF LAND MGMT	200.00	G	0.00	W
F009123S	8	N	12	23	NW	NE	UPPER DAD SPRING	WILLOW SPRING WASH	U.S. BUREAU OF LAND MGMT	200.00	G	0.00	W
S013300 **[8]	8	N	12	23	NW	SE	WILLOW SPRING	COLOSSEUM GORGE	OVERSON, CLAY	1500.00	G	0.00	S
S013301	8	N	13	5	NE	SE	LOWER SNAKE SPRING	COTTONWOOD WASH	OVERSON, CLAY	300.00	G	0.00	S
S013302	8	N	13	5	SE	SE	UPPER SNAKE SPRING	COTTONWOOD WASH	OVERSON, SANDRA	300.00	G	0.00	S
F011201S	8	N	13	7	NW	NW	COTTONWOOD SPRING	COTTONWOOD WASH	U.S. BUREAU OF LAND MGMT	1800.00	G	0.00	S, R, W
S013303	8	N	13	7	NW	NW	COTTONWOOD SPRING 2	COTTONWOOD WASH	OVERSON, CLAY	300.00	G	0.00	S
S013304	8	N	13	9	NE	NE	UNSP	VAN WINKLE WASH	OVERSON, CLAY	75.00	G	0.00	S
F007889S	8	N	13	23	NW	NW	VAN WINKLE SPRING	UNST	U.S. BUREAU OF LAND MGMT	3600.00	G	0.00	S, W
S013305	8	N	13	23	NW	SW	VAN WINKLE SPRING	VAN WINKLE WASH	OVERSON, CLAY	150.00	G	0.00	S
G362429	8	N	17	4	SE	NW			STATE OF CALIFORNIA CALTRANS				
S013306	9	N	12	24	SE	SW	COYOTE SPRING	COTTONWOOD WASH	OVERSON, CLAY	750.00	G	0.00	S
S007948	9	N	12	35	SE	SW	UNSP	BIGHORN BASIN	U.S. BUREAU OF LAND MGMT	100.00	G	0.00	W
S007949	9	N	12	35	NE	NW	UNSP	LOWER BIGHORN BASIN	U.S. BUREAU OF LAND MGMT	100.00	G	0.00	S
S013307	9	N	12	35	NW	SE	BIGHORN SPRING	PLAYGROUND WASH	OVERSON, SANDRA	525.00	G	0.00	S
S007951	9	N	13	14	NW	SE	UNSP **	GOLDFISH TANK SPRING	U.S. BUREAU OF LAND MGMT	100.00	G	0.00	W

[8] ** The two stars at a point indicates that the Sheep Society questions the correctness of the particular item. The corrections are not entered into this table, since the table is left to show the data as legally filed for water rights in Sacramento, even if physically not correct. If the Preserve applies for the rights, correct locations will be essential.

G363379	9	N	13	19	SE	NE			W.L.S.R. INC				
F007950S	9	N	13	22	SE	SW	ARROWWEED SPRING	UNST	U.S. BUREAU OF LAND MGMT	3600.00	G	4.00	W, S
S013308	9	N	13	22	SW	SE	ARROWWEED SPRING	COTTONWOOD WASH	OVERSON, CLAY	3750.00	G	0.00	S
S013309	9	N	13	25	NW	SE	QUAIL SPRING	QUAIL SPRING WASH	OVERSON, CLAY	150.00	G	0.00	S
S013310	9	N	13	25	NW	NW	UPPER QUAIL SPRING	QUAIL SPRING WASH	OVERSON, SANDRA	150.00	G	0.00	S
S013311	9	N	13	30	SW	SW	TWIN SPRINGS	COTTONWOOD WASH	OVERSON, CLAY	300.00	G	0.00	S
S013312	9	N	13	34	SE	NW	HORSE HILLS SPRING	COTTONWOOD WASH	OVERSON, SANDRA	525.00	G	0.00	S
S013313	9	N	14	6	NE	SW	UNSP	WINSTON WASH	OVERSON, CLAY	375.00	G	0.00	S
G362315	10	N	11	6					UNION PACIFIC RAILROAD COMPANY				
S013314	10	N	13	11	SW	NE	UNSP **	WINSTON WASH	OVERSON, CLAY	375.00	G	0.00	S
S007714	10	N	13	12	NW	SW	CORNFIELD SPRINGS		UNION PACIFIC RAILROAD COMPANY				
S013315	10	N	13	12	NW	SW	CORNFIELD SPRING	WINSTON WASH	OVERSON, SANDRA	1500.00	G	0.00	S
F009125S	10	N	13	24	NW	SW	SHEEP SPRING	KELSO WASH	U.S. BUREAU OF LAND MGMT	1800.00	G	0.00	W
F009126S	10	N	13	25	NE	NE	FINGER ROCK SPRING	WINSTON WASH	U.S. BUREAU OF LAND MGMT	3600.00	G	0.00	W
S013316	10	N	13	36	SW	SE	DAM GOOD SPRING	WINSTON WASH	OVERSON, CLAY	75.00	G	0.00	S
S013317	10	N	13	36	SW	SE	PIPE WRENCH SPRING	WINSTON WASH	OVERSON, CLAY	150.00	G	0.00	S
A016214	10	N	14	21	NE	SW	CRYSTAL SPRING	UNST	CALIF DEPT OF PARKS & RECREATION	2640.00	G	0.00	D
A016079	10	N	14	31	SW	SW	GOLDSTONE SPRING	WINSTON WASH	OVERSON, SANDRA	500.00	G	0.00	S
A016126	10	N	14	31	SW	SW	GOLSTONE SPRING	UNST	OVERSON, SANDRA	500.00	G	0.00	S
F011203S	10	N	14	31	SE	SW	GOLDSTONE SPRING	UNST	U.S. BUREAU OF LAND MGMT	1800.00	G	0.00	S, W
A016929	10	N	14	32	NW	NE	FOCHE SPRING	BRISTOL LAKE BASIN	BLAIR, ROB	2000.00	G	0.00	S
A000404	10	N	15	21 **	SW **	SW **	COLTON WELL	UNST	BLAIR, HOWARD	3600.00	G	0.00	S
G362708	11	N	12	25					UNION PACIFIC RAILROAD COMPANY				
S013318	11	N	13	13	SW	NE	BOLDER SPRING	CEDAR WASH	OVERSON, CLAY	300.00	G	0.00	S
S012602	11	N	14	2	NW	NE	DEER SPRINGS **	BRISTOL LAKE	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	S, W
A015271	11	N	14	5	SE	NE	MACEDONIA SPRING	MACEDONIA CANYON	OVERSON, LINDA	410.00	G	0.00	S
S013319	11	N	14	7	NW	NW	UNSP	SUMMIT WASH	OVERSON, CLAY	450.00	G	0.00	S

A016080	11	N	14	9	SE **	NW **	GLOBE SPRING	GLOBE CANYON	OVERSON, SANDRA	120.00	G	0.00	S
A016081	11	N	14	16	SW	NW	SUMMIT SPRING	GLOBE CANYON	OVERSON, SANDRA	300.00	G	0.00	S
A023437	11	N	14	16	SE	NW	SUMMIT SPRING	UNST	STATE OF CALIFORNIA	100.00	G	0.00	W
A017914	11	N	14	30	SW	NE	TOUGH NUT SPRING	KELSO WASH	OVERSON, SANDRA	150.00	G	0.00	S
A018666	11	N	14	35	NE	NW	DOMINGO SPRING	BEECHER CANYON	BLAIR, ROB	3000.00	G	0.00	D, S
F007890S	11	N	15	3	NW	SE	WOODS MOUNTAIN SPRING	FENNER VALLEY	U.S. BUREAU OF LAND MGMT	3600.00	G	0.00	W
S012603	11	N	15	31	SW	SW	UNSP	UNST	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	S, W
A000668	11	N	15	32	NE **	NW	CAVE SPRINGS	UNST	BLAIR, HOWARD	2880.00	G	0.00	S
S012604	11	N	16	1	SE	SW	HACKBERRY SPRING	FENNER VALLEY	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	W
S013429	11	N	16	1	SE	SW	HACKBERRY SPRING	UNST	OVERSON, GARY	3000.00	G	0.00	S
S007893	11	N	16	2	NE **	SE	NEGRO MINE SPRING	FENNER VALLEY	U.S. BUREAU OF LAND MGMT	100.00	G	0.00	W
F007891S	11	N	16	12	NE	NW	SOUTH HACKBERRY SPRING **	BRISTOL LAKE	U.S. BUREAU OF LAND MGMT	2700.00	G	0.00	W
S013430	11	N	17	4	SE	SE	VONTRIGGER SPRING	IVANPAH LAKE	OVERSON, GARY	750.00	G	0.00	S
S013431	11	N	17	5	SE	SE	HOGABOOM WELLS	UNST	OVERSON, GARY	15000.00	G	0.00	S
S013432	11	N	17	7	SE	SW	UNSP	UNST	OVERSON, GARY	225.00	G	0.00	S
A010888	12	N	8	11	SW	NE	SODA STATION SPRINGS	UNST	CURTIS HOWE SPRINGER FOUNDATION	0.14	C	0.00	D, R
S010062	12	N	14	15	SE **	NW **	COYOTE SPRING	CEDAR WASH	OVERSON, GARY	0.00		0.00	S
S010063	12	N	14	15	NE **	SE **	WILDCAT SPRING	CEDAR WASH	OVERSON, GARY	0.00		0.00	S
A017612	12	N	14	22	NE	SE	CHICKEN WATER SPRING	UNST	OVERSON, GARY	400.00	G	0.00	S
S010068	12	N	14	23	NE	SE	SILVER LEAD SPRING	CEDAR WASH	OVERSON, GARY	0.00		0.00	S
S010067	12	N	14	27	NE	SW	MEXICAN WATER SPRING	CEDAR WASH	OVERSON, GARY	0.00		0.00	S
S010066	12	N	14	28	SE	NE	BULLOCK SPRING	CEDAR WASH	OVERSON, LINDA	0.00		0.00	S
S013433	12	N	15	2	SE **	NE **	ROCK SPRINGS	WATSON WASH	OVERSON, LINDA	750.00	G	0.00	S
S013434	12	N	15	3	NW	SW	GOVERNMENT HOLES WELL	UNST	OVERSON, GARY	3750.00	G	0.00	S
S013435	12	N	15	3	NE	SW	GOVERNMENT HOLES WELL	UNST	OVERSON, GARY	3750.00	G	0.00	S
S013436	12	N	15	22	SW	SE	WOODS CANYON SPRING	WOODS WASH	OVERSON, LINDA	225.00	G	0.00	S
A001929	12	N	16	19			NORTH STAR CLAIM	WATSON WASH	OVERSON, LINDA	5760.00	G	0.00	S
S013437	12	N	16	19	NW **	NW	WATSON WELL	UNST	OVERSON, GARY	1500.00	G	0.00	S
S013438	12	N	16	24	SE	SW	BLACK DIAMOND SPRING	UNST	OVERSON, LINDA	300.00	G	0.00	S

S013439	12	N	17	4	NW	NW	EAGLE WELL	UNST	OVERSON, GARY	7500.00	G	0.00	S
S013440	12	N	17	17	NE	SE	LANFAIR WELL	UNST	OVERSON, LINDA	4500.00	G	0.00	S
A006199	12	N	18	13	SE	SE	PIUTE STREAM	PIUTE VALLEY	CALIF DEPT OF FISH & GAME	0.40	C	0.00	D, I
F011205S	12	N	18	24	NW	NW	PIUTE SPRING	UNST	U.S. BUREAU OF LAND MGMT	0.14	C	0.00	S, R, W
A018611	13	N	11	3	SW	SW	INDIAN CREEK	SODA LAKE	BLINCOE FARMS, INC	1500.00	G	0.00	S
A017984	13	N	11	4	NW	SE	CANE SPRINGS	INDIAN CREEK	BLINCOE FARMS, INC	1440.00	G	0.00	S
A018611	13	N	11	9	SW	NW	INDIAN CREEK	SODA LAKE	BLINCOE FARMS, INC	1500.00	G	0.00	S
S012606	13	N	11	9	NW	NE	INDIAN SPRING	SODA LAKE	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	W
S010069	13	N	12	36	SW **	SE **	MARL SPRING	KELSO WASH	OVERSON, LINDA	0.00		0.00	S
S010065	13	N	14	14	SE	SW	BURRO SPRING	KELSO WASH	OVERSON, GARY	0.00		0.00	S
S010060	13	N	14 **	19 **	NW	SE	BECK SPRING	KELSO WASH	OVERSON, GARY	0.00		0.00	S
A017272	13	N	14	23	SW	SW	JASPER SPRING	UNST	OVERSON, GARY	300.00	G	0.00	S
S011349	13	N	15	4			BUTCHER KNIFE CANYON	BUTCHER KNIFE CANYON	OVERSON, GARY	1125.00	G	0.00	S
S011348	13	N	15	8	NW	NW	COTTONWOOD SPRING	IVANPAH LAKE	OVERSON, GARY	3000.00	G	0.00	S
S012607	13	N	15	9	SW	SW	BATHTUB SPRING	UNST	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	S
S010061	13	N	15	16	NW	NW	BATHTUB SPRING	WATSON WASH	OVERSON, LINDA	0.00		0.00	S
A000677	13	N	15	17 **	SW **	NW **	CABIN SPRING	KELSO WASH	OVERSON, GARY	4320.00	G	0.00	D, S
S011206	13	N	15	19	NW	NW	UNSP **	UNST	U.S. BUREAU OF LAND MGMT	1800.00	G	0.00	S, W
S011347	13	N	15	19	SW	NW	LIVE OAK SPRINGS	UNST	OVERSON, GARY	3000.00	G	0.00	S
S013441	13	N	15	36	NE	NE	PAYNE WELLS	WATSON WASH	OVERSON, LINDA	4500.00	G	0.00	S
S012513	13	N	16	7	NE	NE	UNSP	UNST	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	S, W
S013442	13	N	16	7	SW	NW	CARRUTHERS WELL	UNST	OVERSON, GARY	10500.00	G	0.00	S
S013443	13	N	17	18	SW	SW	HEADQUARTERS WELL	UNST	OVERSON, LINDA	7500.00	G	0.00	S
A017988	14	N	11	7	SW	NW	HENRY SPRING	UNST	BLINCOE FARMS, INC	1440.00	G	0.00	S
S012866	14	N	11	7	SW	NW	HENRY SPRING	UNST	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	S, W
A017985	14	N	12	20	SW	NW	BLACK TANK	UNST	BLINCOE FARMS, INC	0.00		2.00	S
A020829	14	N	12	20	SW	NW	BLACK TANK	SODA LAKE	BLINCOE FARMS, INC	0.00		5.70	S
A017987	14	N	13	20	SW	NE	DEER SPRING	UNST	BLINCOE FARMS, INC	2880.00	G	0.00	S
S011345	14	N	13	23	SE	SE	CUT SPRINGS	IVANPAH LAKE	OVERSON, GARY	3000.00	G	0.00	S

S011346	14	N	13	25	NW	SW	WHITE ROCK SPRING	UNST	OVERSON, GARY	9000.00	G	0.00	S
S011343	14	N	14	18	SW **	NW **	KESSLER SPRING	UNST	OVERSON, GARY	23000.00	G	0.00	S
S011344	14	N	14 **	18 **	SW **	NW **	KESSLER SPRING WELLS	UNST	OVERSON, LINDA	23000.00	G	0.00	D, S
G363178	14	N	15	17	SW	NE			VICEROY GOLD CORPORATION				
S013444	14	N	15	23	SW	SE	BRANT SPRING	IVANPAH LAKE	OVERSON, GARY	375.00	G	0.00	S
S013445	14	N	15	27	NE	NW	CLIFF CANYON SPRING	UNST	OVERSON, GARY	750.00	G	0.00	S
S011350	14	N	15	28 **	NW **	NW **	SACATON SPRING	UNST	OVERSON, GARY	750.00	G	0.00	S
A00435	14	N	15	33	NE	SW	CLARK SPRING	IVANPAH LAKE	OVERSON, GARY	3600.00	G	0.00	S
S013446	14	N	15	36	SE	NE	4TH OF JULY CANYON	4TH OF JULY CANYON	OVERSON, GARY	300.00	G	0.00	S
S013447	14	N	16	4 **	SE **	SE **	YOUNG WELL	UNST	OVERSON, GARY	750.00	G	0.00	S
S013448	14	N	16	4	SW	SW	SLAUGHTER HOUSE SPRING	UNST	OVERSON, GARY	1125.00	G	0.00	S
S013449	14	N	16	8	SE	NE	UNSP	IVANPAH LAKE	OVERSON, GARY	225.00	G	0.00	S
S013450	14	N	16	11	NE	NW	HIDDEN SPRING	UNST	OVERSON, GARY	375.00	G	0.00	S
S013451	14	N	16	14	SE	SW	BARNWELL WELLS	UNST	OVERSON, GARY	10500.00	G	0.00	S
A000678	14	N	16	22	NW	SW	LECYR WELL	UNST	OVERSON, GARY	4400.00	G	0.00	S, D
S013452	14	N	16	22	SE	NW	LECYR SPRING	SEARLES LAKE BASIN **	OVERSON, GARY	225.00	G	0.00	S
A000679	14	N	16	28	NE	SE	MAIL SPRING	COLORADO RIVER **	OVERSON, LINDA	4320.00	G	0.00	S, D
S013453	14	N	16	29	SW	NW	HUMMINGBIRD SPRING	UNST	OVERSON, LINDA	225.00	G	0.00	S
S013454	14	N	16	29	NW	SW	KEYSTONE SPRING	UNST	OVERSON, GARY	300.00	G	0.00	S
S013455	14	N	16	31	NE	NW	CARRUTHERS CANYON	CARRUTHERS CANYON	OVERSON, GARY	225.00	G	0.00	S
G363179	14	N	17	16	SE	NE			VICEROY GOLD CORPORATION				
D030264R	15	N	14	21	NW	SE	WHEATON SPRING	WHEATON WASH	DAVIS, DAVID	200.00	G	0.00	D
S013890	15	N	14	21	NW	SE	WHEATON SPRING	WHEATON WASH		200.00	G	0.00	D
G362334	15	N	15	20					MOLYCORP INC				
G362497	15	N	15	20					MOLYCORP INC				
G362742	15	N	15	20					MOLYCORP INC				
G362743	15	N	15	20					MOLYCORP INC				
G362744	15	N	15	20					MOLYCORP INC				
G362767	15	N	15	20					MOLYCORP INC				
G362790	15	N	15	20					MOLYCORP INC				

G362745	15	N	15	21					MOLYCORP INC				
A016964	15	N	15	23	SW	SW	MURPHY WELL	UNST	OVERSON, LINDA	6000.00	G	0.00	S
S013457	15	N	16	36	NE	NE	WILLOW SPRING	WILLOW WASH	OVERSON, GARY	750.00	G	0.00	S
S012868	15	N	17	16	SE	SE	INDIAN SPRING	SUPERIOR VALLEY	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	W, S
S012514	15	N	17	19	SE	SW	DOVE SPRING	UNST	U.S. BUREAU OF LAND MGMT	900.00	G	0.00	W
S013458	15	N	17	19	SE **	SE	DOVE SPRING	UNST	OVERSON, LINDA	750.00	G	0.00	S
A017222	17	N	13	11	NE	SW	MESQUITE SPRING	UNST	DAVIS, EBBIE	400.00	G	0.00	S
A017220	17	N	13	12	SW	NW	BURRO SPRING	IVANPAH LAKE	DAWSON, D	642.00	G	0.00	S
A017216	17	N	13	13	NE	SW	WHISKY STILL SPRING	UNST	DAWSON, D	642.00	G	0.00	S
S012871	17	N	13	14	SW	SW	COLOSSEUM GORGE SPRING	COLOSSEUM GORGE	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	S, W
A017528	17	N	13	15	NE	SW	GREENS WELL	KINGSTON WASH	SMITH, JAN	2000.00	G	0.00	D, B, S
S012872	17	N	13	23	SE	SE	DRIPPING SPRING	UNST	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	S, W
S012873	17	N	13	23	SW	SW	BELL SPRING	IVANPAH LAKE	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	S, W
A017217	17	N	13	24	NW	SW	WILLOW SPRING	COLOSSEUM GORGE	DAWSON, D	642.00	G	0.00	S
A017226	17	N	13	24	SW	SE	IVANPAH SPRING	COLOSSEUM GORGE	DAWSON, D	642.00	G	0.00	S
A017227	17	N	13	24	NW	SE	CAMP WATER SPRING	COLOSSEUM GORGE	DAVIS, EBBIE	600.00	G	0.00	S
S012874	17	N	13	24	SW	SE	IVANPAH SPRING	COLOSSEUM GORGE	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	S, W
S012875	17	N	13	24	NW	SW	IVANPAH SPRING #2	COLOSSEUM GORGE	U.S. BUREAU OF LAND MGMT	1450.00	G	0.00	W, S
A017214	17	N	13	25	NE	NW	HACKBERRY SPRING	UNST	DAWSON, D	500.00	G	0.00	S

WATER RIGHTS CODES RECORD TYPES

1. A - APPLC - APPROPRIATIVE
2. D - SMDOM - SMALL DOMESTIC REG

3. F - FEDRL - FEDERAL FILINGS (RESERVATION RIGHT)
4. G - GRWTR - GROUNDWATER RECORDATION
5. S - STATE - STATEMENT OF DIV & USE

<u>USE TYPES</u>

1. B - MINING
2. C - MILLING
3. D - DOMESTIC
4. E - FIRE PROTECTION
5. I - IRRIGATION
6. J - INDUSTRIAL
7. K - INCIDENTAL POWER
8. P - POWER
9. R - RECREATIONAL
10. S - STOCKWATERING
11. W - FISH & WILDLIFE PROTECTION AND / OR ENHANCEMENT

<u>MISC</u>

1. UNSP - UNNAMED SPRING
2. UNST - UNNAMED STREAM
3. UNXX - OTHER
4. M - MOUNT DIABLO BASE & MERIDIAN
5. S - SAN BERNARDINO BASE & MERIDIAN
6. C - CFS - CUBIC FEET PER SECOND; 646, 317 GALLONS PER DAY (GPD)
7. G - GPD - GALLONS PER DAY; 1.55 CFS
8. DD - DIR/DIV - DIRECT DIVERSION
9. STO - STORAGE

Appendix 3 An excerpt of one of the nine files of springs, seeps, and guzzlers produced by the Society for the Preservation of Bighorn Sheep which relate to the Mojave NP, showing the type of information found in these files. The other eight files and a summary table may be seen in digital form at the Preserve or requested via e-mail.

PROVIDENCE
AREA: PROVIDENCE MTS, COLTON HILLS
0000001050000000000000

---------------------water name	bgg #	twn	rng	#	1/4	1/4	elev	topo quad	land	w	e utm	n utm	grid
ARROWWEED SPR		9	13	22	SE	SE	3950	FLYNN	NPS	N			
BARBER WELL		11	14	27	SW	NW	3800	MID HILLS	NPS	Y			
BEECHER SPR		11	14	16	NE	NE	4600	MID HILLS	NPS	Y			
BIG COTTONWOOD SPR		12	14	14	NE	SW	5000	MID HILLS	NPS	Y			
BLIND SPR		10	14	28	SE	SW	4170	FLYNN	NPS	Y			
BOULDER SPR		12	15	27	NW	NE	4800	MID HILLS	NPS				
BUCKWHEAT SPR		12	15	27	SE	NE	5000	MID HILLS	NPS				
BULLOCK SPR		12	14	28	SE	NE	4600	MID HILLS	NPS	Y			
CABIN TUNNEL SPR		11	14	19	SE	NE	4200	KELSO	?				
CAVE SPR		11	15	32	NW	NW	3859	COLTON WELL	NPS	N	646070	3873470	NAD 27
CEDAR CYN		13	15	31	NE	NE	5100	MID HILLS	NPS				
CHICKEN WATER SPR		12	14	22	SE	NE	4790	MID HILLS	NPS				
COLUMBIA MINE SPR		11	14	3	SE	NW	4600	MID HILLS	NPS				
CORNFIELD MINE SPR		10	13	11	NW	NE	3200	FLYNN	NPS	Y			
CORNFIELD SPR		10	13	12	NW	SW	3500	FLYNN	NPS	Y			
COYOTE TROUGH SPR		12	14	15	SW	SE	4600	MID HILLS	NPS	Y			
DEER WATER SPR		11	14	3	SE	SE	5000	MID HILLS	NPS				
DIXIE QUEEN SPR		11	14	3	NW	SW	4800	MID HILLS	NPS				
DOMINGO SPR		11	14	35	NE	NW	3800	COLTON WELL	NPS	Y			
DOUG SPR		9	14	9	SW	SW	4080	FLYNN	NPS				
ELBOW SPR		11	14	10	SE	SE	5100	MID HILLS	NPS	Y			
FINGER ROCK SPR		10	13	25	NE	NE	4800	FLYNN	NPS	Y			
FOSHAY SPR		10	14	32	SW	NE	4200	FLYNN	NPS				
GLOBE MINE		11	14	9	NW	SE	4800	MID HILLS	NPS	Y			
GOLD VALLEY SPR		12	15	31	NE	SW	5041	MID HILLS		N			
GOLDFISH TANK		9	13	14	SE	NE	4550	FLYNN	NPS	Y			
GOLDSTONE SPR		10	14	31	SE	SW	5400	FLYNN	NPS	Y			
GRANITE SPR		12	15	31	NW	SW	5200	MID HILLS	SCH				
GRANITE WELL SPR		12	14	36	NE	SE	5150	MID HILLS	SCH	N			
HIDDEN SPR		9	14	31	NE	SW	4150	FLYNN	NPS	Y			
HOLLOMAN SPR		9	14	5	NE	NE	4400	FLYNN					
HONEYBEE SEEP		9	13	14	SW	NW	5000	FLYNN	NPS	Y			
IRON CLAIM SPR		11	13	35	SW	NE	3480	FLYNN	NPS	Y			
JO ANNE SPR		9	14	18	SW	SE	5400	FLYNN	NPS	Y			
KRIS SPR		9	14	7	SE	SE	4560	FLYNN	NPS	Y			
LANFAIR TUNNEL		12	16	7	SW		5000	MID HILLS	NPS	N			
LONE TREE SPR		12	14	34	NE	NE	4700	MID HILLS	NPS				
LYONS WELL		11	14	10	SW	NE	5400	MID HILLS	NPS	Y			
MACEDONIA SPR		11	14	5	SE	NE	4080	KELSO	NPS	Y			
MEXICAN WATER SPR		12	14	27	NE	SW	4680	MID HILLS	NPS				
NO NAME SPR		11	13	11	SE	SE	3520	KELSO	NPS				
PICTA SPR		9	13	11	SE	SE	4800	FLYNN	NPS	Y			
PIPE WRENCH SPR		10	13	36	SE	SE	4500	FLYNN		Y			
PROVIDENCE PK SPR		9	13	13	SE	SE	5800	FLYNN	NPS	Y			
QUAIL SPR		9	13	25	NW	SE	3920	FLYNN	NPS	Y			
RED ROCK SPR		12	14	34	SW	SW	4800	MID HILLS	SCH	Y			

RINCH SPR		12	15	14	SE		5100	MID HILLS	NPS	Y			
ROCK SHELTER SPR		11	15	18	SW		4400	MID HILLS	NPS	Y			
ROCK SPR		12	15	1	NW	NW	4800	MID HILLS	NPS	N			
ROTH WELL		11	14	11	NE	NW	4800	MID HILLS	NPS	N			
SHEEP SPR		10	13	24	NE	SW	4700	FLYNN	NPS	Y			
SILVER LEAD SPR		12	14	23	NE	SE	5320	MID HILLS	NPS	Y			
SUMMIT SPR		11	14	16	SW	NE	4680	MID HILLS	CAL	Y			
SUMMIT SPR WASH DAM		11	14	18	NW	SE	4850	KELSO					
TOUGH NUT SPR		11	14	30	NW	SW	3960	KELSO	NPS	Y			
TRAIL SPR		9	13	13	SW	SW	5900	FLYNN	NPS	Y			
UNNAMED		11	15	20	SW	SW	3800	MID HILLS	NPS				
UNNAMED SPR		9	14	30	SW	NW	4200	FLYNN	NPS	Y			
UNNAMED SPR		10	14	32	SW	SE	4440	FLYNN	NPS	Y			
UNNAMED SPR		11	16	7	SW	NE	4200	MID HILLS	NPS	Y			
URSINA SPR		10	14	29	SW	NE	5300	FLYNN	RR	Y			
VICTORY MINE WELL		11	14	16	SW	SW	4800	MID HILLS	NPS	Y			
VULCAN MINE PIT		10	13	25	SE	SE	3800	FLYNN	NPS				
WHISKEY SPR		11	14	26	SE	SE	3960	COLTON WELL	NPS	Y			
WILDCAT SPR		12	14	15	NE	SW	4520	MID HILLS	RR	Y			
WILLOW WELL SPR		11	14	2	NE	NE	4960	MID HILLS	NPS				
WINSTON BASIN SEEP		9	13	1	SE	SE	4500	FLYNN	NPS	Y			
WINSTON BASIN SEEP		9	13	12	NE	SE	4500	FLYNN	NPS	Y			
WINSTON BASIN SEEP		9	14	7	SW	NW	4500	FLYNN	NPS	Y			
WINSTON BASIN SEEP		9	13	1	SW	SE	4500	FLYNN	NPS	Y			

SOURCE: WEAVER RA, MENSCH JL, THOMAS RD, "A REPORT ON DESERT BIGHORN SHEEP IN NE SAN BERNARDINO CO", JULY 1969
MAPS BY FLOYD VERNOY, 1961

ARROWWEED SPR

WILDLIFE BENEFITED: BIRDS ONLY
WORK NEEDED: INSTALL DRINKER NEAR SOURCE TO PROVIDE ACCESS FOR DEER & SHEEP [WEAVER ET AL].

BEECHER SPR

WILDLIFE BENEFITED: DEER, BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK NEEDED: NONE [WEAVER ET AL].

BLIND SPR

WILDLIFE BENEFITED: BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK NEEDED: REDEVELOP & CONSTRUCT BASIN [WEAVER ET AL].

BULLOCK SPR

WATER DESCR: SPRING PIPED INTO COW TROUGH
ROUTE DESCR: AAA SB CO MAP D-10
AT ELORA, MIDWAY BETWEEN KELSO & CIMA, GO UNDER RR TRESTLE AND TAKE L RD AFTER GETTING OUT OF WASH. GO 1.3 TO JCT, THEN GO ON 2.6 TO NEXT JCT, TURN R & GO 0.9 TO MEXICAN WATER SPR. GO E 0.2 TO BULLOCK SPR NEAR CORRAL.
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

CAVE SPR

WATER DESCR: WATER POOLS UP BELOW OVERHANGING ROCK SLAB ACROSS GULLY, PIPED TO COW TROUGH.
ROUTE DESCR: AAA SB CO MAP E-10, 2WD
TAKE ESSEX RD EXIT FROM I-40 & HEAD N. AT ABOUT 6.0 PAST FORK TO MITCHELL CAVERNS IS A HILL CLOSE TO RD ON W SIDE. JUST PAST HILL PULL INTO WASH THAT LOOKS LIKE A RD BUT IS NOT. HEAD 300° & UP FLANK OF WILD HORSE MESA. LOOK FOR CATCLAW & GRAY GRANITIC ROCK IN THIS LAND OF BROWN VOLCANIC.
WILDLIFE BENEFITED: BIRDS
EXOTICA: CATTLE, BURRO
WORK DONE:

WORK NEEDED: INSTALL WILDLIFE DRINKER [WEAVER ET AL]. CANNOT BE FENCED TO EXCLUDE BURRO BECAUSE OF CATTLE USE.
REMARKS: WEAVER GIVES LOCATION IN SE¼ OF NW¼ AT 3700', FOUND NOTHING THERE.

CHICKEN WATER SPR (MORMON TUNNEL)

WATER DESCR: SPRING
ROUTE DESCR: AAA SB CO MAP D-10
AT ELORA, MIDWAY BETWEEN KELSO & CIMA, GO UNDER RR TRESTLE AND TAKE L RD AFTER GETTING OUT OF WASH. GO 1.3 TO JCT, THEN GO ON 2.6, THEN GO L 0.7 TO SPR JUST ABOVE CORRAL.
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

CORNFIELD SPR

WILDLIFE BENEFITED: BIRDS
EXOTICA: BURRO
WORK NEEDED: NONE [WEAVER ET AL].

COYOTE SPR

WATER DESCR: SPRING
ROUTE DESCR: AAA SB CO MAP D-10
FROM CIMA RD GO 4.1 E ON CEDAR CYN RD TO CEDAR CYN WASH. GO DOWN WASH 1.3, THEN TURN L ON VERY DIM RD & GO 2.3 TO WILDCAT SPR. TURN R & GO 0.4 AROUND HILL.
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT,, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

FINGER ROCK SPR

SOURCE: LES COOMBES
WATER DESCR: SPRING IN HILLSIDE
ROUTE DESCR: AAA SB CO MAP E-9
AT VULCAN MINE A RD GOES UP & AROUND THE E SIDE OF THE PIT. GO TO END OF THIS RD, THEN HIKE NE CROSSING A CYN & OVER NEXT RIDGE.
WILDLIFE BENEFITED: BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK DONE: DFG & SCBS CLEARED BRUSH AWAY FROM SITE WHERE SPRINGBOX & PIPE HAD ONCE BEEN INSTALLED BY DFG.
WORK NEEDED: CLEAR BRUSH OCCASIONALLY

FOSHAY SPR

WILDLIFE BENEFITED: BIRDS
WORK NEEDED: INSTALL DRINKER AT SOURCE [WEAVER ET AL].

GOLDFISH TANK SPR

WILDLIFE BENEFITED: BIRDS, DEER(?)
EXOTICA: BURRO
WORK NEEDED: BOX & PIPE TO DRINKER [WEAVER ET AL].

GOLDSTONE SPR

WILDLIFE BENEFITED: BIRDS, DEER, SHEEP
EXOTICA: BURRO
WORK NEEDED: CONSTRUCT BASIN [WEAVER ET AL].

HOLLOMAN SPR

SOURCE: LES COOMBES
WATER DESCR: SPRING BOX IN GULLY, ORIGINALLY DEVELOPED FOR CATTLE.
ROUTE DESCR: AAA SB CO MAP E-9
START FROM RD ABOUT 2 MI E OF FOSHAY PASS.
WILDLIFE BENEFITED: SHEEP
EXOTICA: BURRO
WORK DONE: DFG LED A PARTY HERE TO DIG OUT & REPAIR SPRING BOX, ca 1992.
WORK NEEDED:
REMARKS: NAMED FOR BOB HOLLIMAN?

HONEYBEE SEEP

WILDLIFE BENEFITED: BIRDS, DEER
EXOTICA: BURRO

WORK NEEDED: CHECK FOR PERMANENCE; CONSTRUCT SMALL CATCHMENT [WEAVER ET AL].

JO ANNE SPR

WILDLIFE BENEFITED: SHEEP, DEER, BIRDS
WORK NEEDED: BOX OR TILE, CONSTRUCT BASIN [WEAVER ET AL].

KRIS SPR

WILDLIFE BENEFITED: BIRDS, SHEEP(?)
WORK NEEDED: CHECK FOR PERMANENCE; BOX & PIPE TO BASIN [WEAVER ET AL].

LYONS WELL

WILDLIFE BENEFITED: DEER, BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK NEEDED: NONE [WEAVER ET AL].

MEXICAN WATER

WATER DESCR: SPRING IN TUNNEL
ROUTE DESCR: AAA SB CO MAP D-10
AT ELORA, MIDWAY BETWEEN KELSO & CIMA, GO UNDER RR TRESTLE AND TAKE L RD AFTER GETTING OUT OF WASH. GO 1.3 TO JCT, THEN GO ON 2.6 TO NEXT JCT, TURN R & GO 0.9 TO MEXICAN WATER SPR.
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

QUAIL SPR

WATER DESCR: NONE, DRY [WEAVER ET AL, 1969]

SHEEP SPR

WILDLIFE BENEFITED: SHEEP, DEER, BIRDS
EXOTICA: BURRO
WORK NEEDED: NONE

SILVER LEAD SPR

WATER DESCR: SPRING IN MINE SHAFT
ROUTE DESCR: AAA SB CO MAP D-10
FROM CIMA RD GO 4.1 E ON CEDAR CYN RD TO CEDAR CYN WASH. GO DOWN WASH 0.5, TURN L UP NARROW WASH & GO 3.3 TO JCT WITH RD FROM BLACK CYN. GO ON 0.4 TO NEXT JCT. TURN R & GO 0.4 DOWN RD TO SPR.
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

SUMMIT SPR

WILDLIFE BENEFITED: DEER, BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK NEEDED: NONE [WEAVER ET AL].

TOUGH NUT SPR

WILDLIFE BENEFITED: DEER
EXOTICA: BURRO
WORK NEEDED: INSTALL DRINKER AT SOURCE [WEAVER ET AL].

TRAIL SPR

WATER DESCR: NONE, DRY [WEAVER ET AL, 1969].

UNNAMED SPR [T10 R14 #32]

WILDLIFE BENEFITED: SHEEP, DEER
EXOTICA: BURRO
WORK NEEDED: CHECK FOR PERMANENCE [WEAVER ET AL].

URSINA SPR

WILDLIFE BENEFITED: UNKNOWN, NOT CHECKED [WEAVER ET AL].

VULCAN MINE PIT

WATER DESCR: POND IN BOTTOM OF MINE PIT.
ROUTE DESCR:
WILDLIFE BENEFITED: SHEEP, BIRDS
EXOTICA: BURRO
WORK NEEDED: NONE [WEAVER ET AL]

WILDCAT SPR (BOBCAT)

WATER DESCR: SPRING
ROUTE DESCR: AAA SB CO MAP D-10
FROM CIMA RD GO 4.1 E ON CEDAR CYN RD TO CEDAR CYN WASH. GO DOWN WASH 1.3, THEN TURN L ON VERY DIM RD & GO 2.3 TO SPR
WILDLIFE BENEFITED: QUAIL, DOVE, RABBIT, DEER, CHUKAR
EXOTICA: CATTLE
REMARKS:

WINSTON BASIN SEEPS

WILDLIFE BENEFITED: UNKNOWN
WORK NEEDED: DEVELOPMENT NEEDED; CHECK FOR PERMANENCE [WEAVER ET AL].

WINSTON BASIN SPR

WILDLIFE BENEFITED: DEER, BIRDS, SHEEP(?)
EXOTICA: BURRO
WORK NEEDED: BOX OR TILE, PIPE TO BASIN [WEAVER ET AL].

Appendix 4 Spring discharges from the U.S. Geological Survey database (USGS, San Diego office, courtesy of Julia Huff, 1998), with added data and notes inserted from Freiwald, 1984, and from Moyle, 1972. GPM = gallons per minute. Some of the readings were measured volumetrically and others were estimated, according to the records.

SPRING NUMBER DATA MEASURED	SITE-ID	DATE DISCHARGE MEASURED	DISCHARGE (GPM)	NOTES
008N013E08RS01S	344737115375501	08-05-81	.01	“BLM Spring” (4,050 ft)
008N013E17MS1		8-4-81	.02	Dripping Spring
008N013E23DS01S	344629115352901	10- -71	.05	Van Winkle Spr
		01- -72	.50	(by Granite Mt)
		07- -73	.02	(3,600 ft)
		04- -74	.12	
		8 - 81	.02	
009N014E03CS02S	345413115302002	08-06-81	.58	(no name given)
010N014E31QS01S	345429115330501	- -60	.38	A spring near
		07- -68	.21	Foshay Pass
		03- -73	.33	
		02-15-78	.33	
		06-22-78	.38	
		08-11-81	1.00	
010N014E32GS02S	345502115320301	02- 1-71	.66	Foshay Spring
		05- 1-71	.32	(4,190 ft)
		01-14-76	.09	
		06-22-78	.83	
		08-11-81	.01	
011N014E26RS01S	345952115265601	07-23-81	.13	Whiskey Spring (3,960 ft)
011N016E01PS01S	350331115125401	11- 1-17	3.50	Hackberry Spring
		- -60	.25	(Hackberry Mts)
		10- -71	.38	(4,440 ft)
		10- -72	.02	
		08- -73	.17	
		03-09-78	1.66	
011N017E04RS01S	350320115084901	- -18	5.00	Vontrigger Spring (Vontrigger Hills) (3,550 ft)
012N015E01ES01S	350910115194801	- -09	1.00	Rock Spring
		08-21-81	2.00	(Mid Hills) (4,800 ft)
012N015E27BS01S	350544115211701	03-23-78	.08	Boulder Spring
		08-19-81	.23	(Mid Hills) (4,820 ft)
012N018E24DS01S	350639114594601	-09	1.00	Piute Spring
		06- -60	50.00	(east edge Preserve)
		4-15-80	390.00	
		09-02-81	62.30	(3,000 ft)
		1-28-82		172.80
013N15E04PS1		12-4-69	.5	Butcherknife Spring (Mid Hills) (5,360 ft)
013N15E08ES1		12-4-69	.28	Cottonwood Spring (Mid Hills) (5,280 ft)
013N015E09NS01S	351258115175601	08-14-81	.04	Bathtub Spring (Mid Hills)

				(5,830 ft)
013N15E18BS1		12-4-69	.06	Cabin Spring (Mid Hills) (5,480 ft)
014N13E23RS1		12-2-69	.13	Cut Spring (Cima area) (5,160 ft)
014N15E23KS1		1-7-70	.19	Garvanza Spring (Ivanpah area) (4,360)
014N15E29AS1		1-7-70	.06	Sacaton Spring (NY Mts) (4,200 ft)
014N16E09DS1		1-8-70	.38	Slaughterhouse Spr. (NY Mts/Ivanpah) (4,120 ft)
014N16N28JS2		1 -1-60 5-1-70 1-31-78	.08 1.00 .58	Mail Spring
014N16E29MS01S	351557115172601	08-25-81	.02	Keystone Spring (New York Mts) (5,830 ft)
015N14E02MS1		11-7-69	.10	Mineral Spring (Ivanpah Mts) (4,360 ft)
015N14E-64BS1		10-28-69	.56	Wheaton Spring (Ivanpah Mts) (4,480 ft)
015N017E16RS01S	352227115084301	- -60 - -68 05- -70 05- -71 08- -71 12- -73 02-01-78 06-20-78 08-26-81	.05 .01 3.00 .00 .00 .02 .00 .00 1.00	Indian Spring (N. New York Mts) (5,010 ft)
015N17E19NS1		1-19-70	.94	Dove Spring (NY Mts) (5,000 ft)
015N017E22AS01S	352218115073601	07- -72 01- -73 12- -73 02-01-78 08-26-81	.50 .50 .50 1.00 .33	Malpais Spring # 2 (N.New York Mts (4,680 ft)

015N017E27HS01S	352119115074901	02- -71	1.00	Coates Spring
		08- -71	.01	(N. New York Mts)
		03- -72	.03	(4,640 ft)
		07- -73	.01	
		12- -73	.01	
		08-26-81	1.00	
016N13E24LS1		11-08-69	1.95	Mescal Spring (Mt Pass area) (4,840 ft)
016N13E24RS1		11-8-69	.63	Groaner Spring (Mt Pass area) (4,640)
017N13E26AS1		11-5-69	2.25	No name given (Clark Mts)

See notes on p 29 regarding flows of Cornfield Spring, near Kelso **Cornfield Spring**

Nov 1, 1998

(Page 109) Appendix 5. U.S.Geological Survey water quality data for the Mojave National Preserve area.

Example No. 1, Site No.22---STATION NUMBER: 350320115084901 STATION NAME: 011N017E04RS01S [Vontrigger Spring at Vontrigger Hills]

STATE: CALIFORNIA COUNTY: SAN BERNARDINO
LATITUDE/LONGITUDE: 350320 1150849

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM JUN 1952 TO SEPT 1981

PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN

DESCRIPTIVE STATISTICS

WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	(MEDIAN)
00010 WATER TEMPERATUR (DEGREES)	2	26.000	20.000	--	--
00027 COLLECTING AGENC (CODE NUMBER)	4	9816.000	1028.000	--	--
00028 ANALYZING AGENCY (CODE NUMBER)	4	80020.000	9816.000	--	--
00095 SPECIFIC CONDUCT US/CM @ 25C	4	394.000	353.000	--	--
00400 PH, WH, FIELD (STANDARD UNIT	4	7.900	7.100	--	--
00403 PH, WH, LABORATO (STANDARD UNIT	1	7.500	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	4	13.000	1.900	--	--
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	3	97.000	95.000	--	--
00445 ANC CARB FET FIE (MG/L AS CO3)	3	0.000	--	--	--
00631 NO2 + NO3 DISSOL (MG/L AS N)	1	4.100	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	4	110.000	97.000	--	--
00915 CALCIUM DISSOLVE (MG/L AS CA)	4	37.000	28.000	--	--
00925 MAGNESIUM DISSOL (MG/L AS MG)	4	7.000	4.400	--	--
00930 SODIUM DISSOLVED (MG/L AS NA)	4	33.000	28.000	--	--
00931 SODIUM ADSORPTIO (RATIO)	4	1.000	1.000	--	--
00932 SODIUM, PERCENT PERCENT	4	39.000	37.000	--	--
00935 POTASSIUM DISSOL (MG/L AS K)	3	6.900	5.700	--	--
00940 CHLORIDE DISSOLV (MG/L AS CL)	4	47.000	37.000	--	--
00945 SULFATE DISSOLVE (MG/L AS SO4)	4	32.000	21.000	--	--
00950 FLUORIDE DISSOLV (MG/L AS F)	3	0.700	0.500	--	--
00955 SILICA DISSOLVED (MG/L AS SIO2)	2	77.000	48.000	--	--
01000 ARSENIC DISSOLVE (UG/L AS AS)	1	9.000	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	4	520.000	100.000	--	--
01046 IRON DISSOLVED (UG/L AS FE)	1	<10.000	--	--	--
70300 RESIDUE DIS 180C MG/L	4	303.000	218.000	--	--
70301 DISSOLVED SOLIDS MG/L	3	307.000	177.000	--	--
70303 RESIDUE DIS TON/ T/AC-FT	3	0.410	0.300	--	--
71850 N, NITRATE TOTAL MG/L AS NO3	3	27.000	13.000	--	--
72000 ELEV.LSD(FT.AB.N FT (NGVD)	4	3550.000	3550.000	--	--
90095 SPECIFIC CONDUCT MICROSIEMENS/C	1	402.000	--	--	--
90410 ANC, TIT. 4.5, L MG/L AS CACO3	4	86.000	78.000	--	--
95902 HARDNESS, NONCAR (MG/L AS CACO3	4	31.000	19.000	--	--

(page 110) Example No. 2, Site Number 28--- STATION NUMBER: 350849115213001 STATION NAME: 012N015E03L001S
[Well Mid Hills, high elevation area]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 350849 1152130

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM JUN 1952 TO AUG 1981

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00010 WATER TEMPERATUR (DEGREES)	13	21.000	12.000	16.000	21.000	18.250	16.000	14.000	12.000
00027 COLLECTING AGENC (CODE NUMBER)	14	9816.000	1028.000	9188.286	9816.000	9816.000	9816.000	9816.000	1028.000
00028 ANALYZING AGENCY (CODE NUMBER)	14	80020.000	9816.000	14830.571	80020.000	9816.000	9816.000	9816.000	9816.000
00095 SPECIFIC CONDUCT US/CM @ 25C	14	1100.000	724.000	907.286	1100.000	996.000	919.500	810.750	724.000
00400 PH, WH, FIELD (STANDARD UNIT	14	8.100	7.200	7.750	8.100	8.000	7.800	7.575	7.200
00403 PH, WH, LABORATO (STANDARD UNIT	1	7.500	--	--	--	--	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	14	56.000	6.100	17.086	56.000	19.000	12.000	7.175	6.100
00410 ANC, FET, FIELD (MG/L AS CACO3	1	326.000	--	--	--	--	--	--	--
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	13	550.000	370.000	451.538	550.000	485.000	460.000	415.000	370.000
00445 ANC CARB FET FIE (MG/L AS CO3)	11	0.000	--	--	--	--	--	--	--
00631 NO2 + NO3 DISSOL (MG/L AS N)	1	0.140	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	14	370.000	270.000	310.000	370.000	332.500	310.000	280.000	270.000
00902 NONCARBONATE HAR (MG/L AS CACO3	1	0.000	--	--	--	--	--	--	--
00915 CALCIUM DISSOLVE (MG/L AS CA)	11	95.000	68.000	78.909	95.000	86.000	75.000	74.000	68.000
00925 MAGNESIUM DISSOL (MG/L AS MG)	11	35.000	22.000	28.636	35.000	32.000	31.000	24.000	22.000
00930 SODIUM DISSOLVED (MG/L AS NA)	11	145.000	62.000	96.091	145.000	108.000	97.000	76.000	62.000
00931 SODIUM ADSORPTIO (RATIO)	11	3.000	2.000	2.273	3.000	3.000	2.000	2.000	2.000
00932 SODIUM, PERCENT PERCENT	10	45.000	33.000	39.300	45.000	41.250	39.000	37.000	33.000
00935 POTASSIUM DISSOL (MG/L AS K)	10	39.000	0.800	5.350	39.000	2.025	1.950	1.225	0.800
00940 CHLORIDE DISSOLV (MG/L AS CL)	14	75.000	41.000	56.500	75.000	63.750	57.500	45.750	41.000
00945 SULFATE DISSOLVE (MG/L AS SO4)	11	90.000	14.000	52.091	90.000	75.000	49.000	32.000	14.000
00950 FLUORIDE DISSOLV (MG/L AS F)	12	2.600	0.400	1.575	2.600	1.775	1.550	1.225	0.400
00955 SILICA DISSOLVED (MG/L AS SIO2)	6	78.000	29.000	48.333	78.000	60.000	47.500	32.750	29.000
01000 ARSENIC DISSOLVE (UG/L AS AS)	1	1.000	--	--	--	--	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	11	800.000	0.400	385.491	800.000	460.000	400.000	300.000	0.400
01046 IRON DISSOLVED (UG/L AS FE)	1	28.000	--	--	--	--	--	--	--
70300 RESIDUE DIS 180C MG/L	9	768.000	497.000	619.556	768.000	674.500	612.000	567.000	497.000
70301 DISSOLVED SOLIDS MG/L	10	809.000	423.000	585.600	809.000	656.750	589.500	456.500	423.000
70303 RESIDUE DIS TON/ T/AC-FT	10	1.040	0.570	0.817	1.040	0.910	0.820	0.733	0.570

71850 N, NITRATE TOTAL MG/L AS NO3	10	7.400	0.000	2.360	7.400	5.075	1.000	0.000	0.000
72000 ELEV.LSD(FT.AB.N FT (NGVD)	15	5040.000	5040.000	5040.000	5040.000	5040.000	5040.000	5040.000	5040.000
72008 DEPTH OF WELL IN FT	15	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000
90095 SPECIFIC CONDUCT MICROSIEMENS/C	1	1130.000	--	--	--	--	--	--	--
90410 ANC, TIT. 4.5, L MG/L AS CACO3	14	480.000	305.000	378.786	480.000	405.250	381.000	344.000	305.000
95902 HARDNESS, NONCAR (MG/L AS CACO3	14	0.000	--	--	--	--	--	--	--

Example No. 3, Site Number 34---

STATION NUMBER: 350650115181803 STATION NAME: 012N016E19C001S

DRAINAGE [Shallow Well by Hackberry area]

STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 350650 1151818

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM MAY 1960 TO MAY 1964

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00010 WATER TEMPERATUR (DEGREES)	2	20.000	19.500	--	--	--	--	--	--
00027 COLLECTING AGENC (CODE NUMBER)	5	9816.000	9816.000	--	--	--	--	--	--
00028 ANALYZING AGENCY (CODE NUMBER)	5	9816.000	9816.000	--	--	--	--	--	--
00095 SPECIFIC CONDUCT US/CM @ 25C	5	658.000	375.000	--	--	--	--	--	--
00400 PH, WH, FIELD (STANDARD UNIT	5	8.500	7.900	--	--	--	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	5	6.300	0.900	--	--	--	--	--	--
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	5	320.000	140.000	--	--	--	--	--	--
00445 ANC CARB FET FIE (MG/L AS CO3)	4	12.000	0.000	--	--	--	--	--	--
00650 PHOSPHATE TOTAL (MG/L AS PO4)	1	0.500	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	4	160.000	110.000	--	--	--	--	--	--
00915 CALCIUM DISSOLVE (MG/L AS CA)	4	38.000	30.000	--	--	--	--	--	--
00925 MAGNESIUM DISSOL (MG/L AS MG)	4	17.000	9.000	--	--	--	--	--	--
00930 SODIUM DISSOLVED (MG/L AS NA)	4	85.000	36.000	--	--	--	--	--	--
00931 SODIUM ADSORPTIO (RATIO)	4	3.000	1.000	--	--	--	--	--	--
00932 SODIUM, PERCENT PERCENT	4	52.000	41.000	--	--	--	--	--	--
00935 POTASSIUM DISSOL (MG/L AS K)	4	3.100	1.400	--	--	--	--	--	--
00940 CHLORIDE DISSOLV (MG/L AS CL)	5	35.000	20.000	--	--	--	--	--	--
00945 SULFATE DISSOLVE (MG/L AS SO4)	4	38.000	24.000	--	--	--	--	--	--
00950 FLUORIDE DISSOLV (MG/L AS F)	3	1.800	0.500	--	--	--	--	--	--
00955 SILICA DISSOLVED (MG/L AS SIO2)	3	40.000	34.000	--	--	--	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	3	320.000	130.000	--	--	--	--	--	--
70301 DISSOLVED SOLIDS MG/L	4	401.000	243.000	--	--	--	--	--	--
70303 RESIDUE DIS TON/ T/AC-FT	4	0.550	0.330	--	--	--	--	--	--
71850 N, NITRATE TOTAL MG/L AS NO3	4	4.200	0.000	--	--	--	--	--	--
72000 ELEV.LSD(FT.AB.N FT (NGVD)	5	4610.000	4610.000	--	--	--	--	--	--
72008 DEPTH OF WELL IN FT	5	30.000	30.000	--	--	--	--	--	

90410 ANC, TIT. 4.5, L MG/L AS CACO3	5	258.000	137.000	--	--	--	--	--	--
95902 HARDNESS, NONCAR (MG/L AS CACO3	4	0.000	--	--	--	--	--	--	--

(Page 112) Example No.4, Site Number 37--- STATION NUMBER: 350923115093501 STATION NAME:
012N017E04D001S DRAINAGE (Deep well, Lanfair area]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 350923 1150935

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM JAN 1953 TO SEPT 1981

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00010 WATER TEMPERATUR (DEGREES)	12	26.000	20.000	22.042	26.000	23.750	21.500	20.000	20.000
00027 COLLECTING AGENC (CODE NUMBER)	18	9816.000	1028.000	9327.777	9816.000	9816.000	9816.000	9816.000	1028.000
00028 ANALYZING AGENCY (CODE NUMBER)	17	80020.000	9816.000	13945.647	80020.000	9816.000	9816.000	9816.000	9816.000
00095 SPECIFIC CONDUCT US/CM @ 25C	18	450.000	355.000	402.722	450.000	415.250	405.500	390.500	355.000
00400 PH, WH, FIELD (STANDARD UNIT	18	8.500	7.400	7.889	8.500	8.200	7.800	7.575	7.400
00403 PH, WH, LABORATO (STANDARD UNIT	1	7.900	--	--	--	--	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	18	12.000	0.800	4.883	12.000	7.775	4.550	1.850	0.800
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	17	200.000	170.000	181.765	200.000	190.000	180.000	175.000	170.000
00445 ANC CARB FET FIE (MG/L AS CO3)	16	10.000	0.000	1.813	10.000	1.500	0.000	0.000	0.000
00631 NO2 + NO3 DISSOL (MG/L AS N)	1	3.400	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	15	150.000	130.000	139.333	150.000	150.000	140.000	130.000	130.000
00915 CALCIUM DISSOLVE (MG/L AS CA)	10	48.000	24.000	34.800	48.000	38.750	34.500	29.250	24.000
00925 MAGNESIUM DISSOL (MG/L AS MG)	10	16.000	7.600	12.660	16.000	15.250	13.000	11.000	7.600
00930 SODIUM DISSOLVED (MG/L AS NA)	10	42.000	28.000	34.900	42.000	37.500	34.500	32.750	28.000
00931 SODIUM ADSORPTIO (RATIO)	10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
00932 SODIUM, PERCENT PERCENT	10	38.000	28.000	34.600	38.000	37.250	35.000	33.000	28.000
00935 POTASSIUM DISSOL (MG/L AS K)	10	4.000	2.000	3.300	4.000	3.725	3.550	2.975	2.000
00940 CHLORIDE DISSOLV (MG/L AS CL)	18	31.000	18.000	23.444	31.000	24.250	23.000	22.000	18.000
00945 SULFATE DISSOLVE (MG/L AS SO4)	10	23.000	12.000	17.800	23.000	23.000	16.500	14.750	12.000
00950 FLUORIDE DISSOLV (MG/L AS F)	10	0.960	0.200	0.486	0.960	0.600	0.500	0.350	0.200
00955 SILICA DISSOLVED (MG/L AS SIO2)	5	46.000	28.000	--	--	--	--	--	--
01000 ARSENIC DISSOLVE (UG/L AS AS)	1	4.000	--	--	--	--	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	10	170.000	80.000	135.000	170.000	160.000	150.000	110.000	80.000
01046 IRON DISSOLVED (UG/L AS FE)	1	33.000	--	--	--	--	--	--	--
07000 TRITIUM TOTAL (PCI/L)	1	<0.010	--	--	--	--	--	--	--
70300 RESIDUE DIS 180C MG/L	10	313.000	23.000	249.200	313.000	293.500	265.500	242.750	23.000
70301 DISSOLVED SOLIDS MG/L	10	293.000	202.000	240.200	293.000	266.750	237.500	211.750	202.000
70303 RESIDUE DIS TON/ T/AC-FT	10	0.430	0.030	0.339	0.430	0.395	0.360	0.330	0.030
71850 N, NITRATE TOTAL MG/L AS NO3	9	14.000	8.300	11.244	14.000	13.000	11.000	9.450	8.300

72000 ELEV.LSD(FT.AB.N FT (NGVD)	18	3980.000	3980.000	3980.000	3980.000	3980.000	3980.000	3980.000	3980.000
72008 DEPTH OF WELL IN FT	18	700.000	700.000	700.000	700.000	700.000	700.000	700.000	700.000
90095 SPECIFIC CONDUCT MICROSIEMENS/C	1	432.000	--	--	--	--	--	--	--
90410 ANC, TIT. 4.5, L MG/L AS CACO3	18	167.000	146.000	151.500	167.000	153.000	150.000	149.500	146.000
95902 HARDNESS, NONCAR (MG/L AS CACO3	15	35.000	0.000	6.667	35.000	3.000	0.000	0.000	0.000

* - VALUE IS ESTIMATED BY USING A LOG-PROBABILITY REGRESSION TO PREDICT
THE VALUES OF DATA BELOW THE DETECTION LIMIT

NOTE: MULTIPLE DETECTION LIMITS DURING THE PERIOD OF RECORD MAY RESULT IN VARYING VALUES
FLAGGED WITH A "<"

(page 113) Example No. 5, Site Number 40---

STATION NUMBER: 351345116043001 STATION NAME:
013N008E12H001S DRAINAGE Well, Soda Lake area Bhigh in minerals]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 351345 1160430

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM APR 1979 TO APR 1979

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00028 ANALYZING AGENCY (CODE NUMBER)	1	80020.000	--	--	--	--	--	--	--
00410 ANC, FET, FIELD (MG/L AS CACO3	1	460.000	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	1	190.000	--	--	--	--	--	--	--
00902 NONCARBONATE HAR (MG/L AS CACO3	1	0.000	--	--	--	--	--	--	--
00915 CALCIUM DISSOLVE (MG/L AS CA)	1	26.000	--	--	--	--	--	--	--
00925 MAGNESIUM DISSOL (MG/L AS MG)	1	31.000	--	--	--	--	--	--	--
00930 SODIUM DISSOLVED (MG/L AS NA)	1	1200.000	--	--	--	--	--	--	--
00931 SODIUM ADSORPTIO (RATIO)	1	38.000	--	--	--	--	--	--	--
00932 SODIUM, PERCENT PERCENT	1	93.000	--	--	--	--	--	--	--
00935 POTASSIUM DISSOL (MG/L AS K)	1	15.000	--	--	--	--	--	--	--
00940 CHLORIDE DISSOLV (MG/L AS CL)	1	1600.000	--	--	--	--	--	--	--
00945 SULFATE DISSOLVE (MG/L AS SO4)	1	13.000	--	--	--	--	--	--	--
00950 FLUORIDE DISSOLV (MG/L AS F)	1	1.400	--	--	--	--	--	--	--
00955 SILICA DISSOLVED (MG/L AS SIO2)	1	9.000	--	--	--	--	--	--	--
70300 RESIDUE DIS 180C MG/L	1	3230.000	--	--	--	--	--	--	--
70301 DISSOLVED SOLIDS MG/L	1	3170.000	--	--	--	--	--	--	--
70303 RESIDUE DIS TON/ T/AC-FT	1	4.390	--	--	--	--	--	(Page 113)	--

(Page 114) Example No. 6, Site 58--- STATION NUMBER: 351644115150201 STATION NAME: 014N016E22M001S
DRAINAGE AREA: -999999 SQ MI
[Shallow, hard water well, NY Mts area]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 351644 1151502

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM NOV 1917 TO MAY 1964

		DESCRIPTIVE STATISTICS			PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00010 WATER TEMPERATUR (DEGREES)	11	21.000	12.000	15.545	21.000	16.000	15.000	14.000	12.000
00027 COLLECTING AGENC (CODE NUMBER)	16	9816.000	1028.000	9266.750	9816.000	9816.000	9816.000	9816.000	1028.000
00028 ANALYZING AGENCY (CODE NUMBER)	16	9816.000	1028.000	9266.750	9816.000	9816.000	9816.000	9816.000	1028.000
00095 SPECIFIC CONDUCT US/CM @ 25C	15	3050.000	1750.000	2490.667	3050.000	2730.000	2480.000	2360.000	1750.000
00400 PH, WH, FIELD (STANDARD UNIT	15	8.200	6.900	7.553	8.200	7.700	7.500	7.400	6.900
00405 CARBON DIOXIDE D (MG/L AS CO2)	15	37.000	1.500	11.267	37.000	15.000	11.000	7.000	1.500
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	16	250.000	98.000	204.875	250.000	230.000	220.000	182.500	98.000
00445 ANC CARB FET FIE (MG/L AS CO3)	14	0.000	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	16	1400.000	910.000	1140.625	1400.000	1200.000	1150.000	1025.000	910.000
00915 CALCIUM DISSOLVE (MG/L AS CA)	12	420.000	270.000	341.667	420.000	377.500	345.000	302.500	270.000
00925 MAGNESIUM DISSOL (MG/L AS MG)	12	82.000	55.000	69.250	82.000	74.000	70.000	64.750	55.000
00930 SODIUM DISSOLVED (MG/L AS NA)	12	228.000	148.000	197.750	228.000	223.750	206.000	175.000	148.000
00931 SODIUM ADSORPTIO (RATIO)	12	3.000	2.000	2.583	3.000	3.000	3.000	2.000	2.000
00932 SODIUM, PERCENT PERCENT	11	32.000	25.000	27.364	32.000	28.000	27.000	26.000	25.000
00935 POTASSIUM DISSOL (MG/L AS K)	11	7.700	4.500	5.800	7.700	6.000	5.500	5.300	4.500
00940 CHLORIDE DISSOLV (MG/L AS CL)	16	210.000	120.000	174.375	210.000	190.000	180.000	162.500	120.000
00945 SULFATE DISSOLVE (MG/L AS SO4)	12	1300.000	850.000	1109.167	1300.000	1200.000	1100.000	1025.000	850.000
00950 FLUORIDE DISSOLV (MG/L AS F)	11	1.600	0.800	1.058	1.600	1.200	1.000	0.840	0.800
00955 SILICA DISSOLVED (MG/L AS SIO2)	6	30.000	19.000	26.667	30.000	29.250	28.000	24.250	19.000
01020 BORON DISSOLVED (UG/L AS B)	11	940.000	190.000	462.727	940.000	550.000	480.000	300.000	190.000
70300 RESIDUE DIS 180C MG/L	10	2530.000	1680.000	2122.000	2530.000	2300.000	2150.000	1997.500	1680.000
70301 DISSOLVED SOLIDS MG/L	12	2430.000	1560.000	2025.000	2430.000	2172.500	2050.000	1967.500	1560.000
70303 RESIDUE DIS TON/ T/AC-FT	11	3.440	2.280	2.864	3.440	3.110	2.920	2.670	2.280
71850 N, NITRATE TOTAL MG/L AS NO3	12	9.400	0.000	2.815	9.400	4.900	2.100	0.020	0.000
72000 ELEV.LSD(FT.AB.N FT (NGVD)	16	4920.000	4920.000	4920.000	4920.000	4920.000	4920.000	4920.000	4920.000
72008 DEPTH OF WELL IN FT	16	14.500	14.500	14.500	14.500	14.500	14.500	14.500	14.500
90410 ANC, TIT. 4.5, L MG/L AS CACO3	16	201.000	80.000	167.500	201.000	186.750	181.500	150.750	80.000
95902 HARDNESS, NONCAR (MG/L AS CACO3	16	1300.000	810.000	1041.875	1300.000	1200.000	990.000	935.000	810.000

(Page 115) Example No. 7, Site 21--- STATION NUMBER: 350331115125401 STATION NAME: 011N016E01PS01S
DRAINAGE AREA: -999999 SQ MI
[Hackberry Spring]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 350331 1151254
STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM MAY 1955 TO AUG 1981

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00010 WATER TEMPERATUR (DEGREES)	2	22.000	20.000	--	--	--	--	--	--
00027 COLLECTING AGENC (CODE NUMBER)	12	9816.000	1028.000	9083.667	9816.000	9816.000	9816.000	9816.000	1028.000
00028 ANALYZING AGENCY (CODE NUMBER)	12	80020.000	9816.000	15666.333	80020.000	9816.000	9816.000	9816.000	9816.000
00095 SPECIFIC CONDUCT US/CM @ 25C	11	335.000	190.000	217.273	335.000	227.000	200.000	197.000	190.000
00400 PH, WH, FIELD (STANDARD UNIT	11	8.200	7.000	7.536	8.200	7.900	7.500	7.100	7.000
00403 PH, WH, LABORATO (STANDARD UNIT	1	7.900	--	--	--	--	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	11	10.000	0.800	4.245	10.000	7.600	2.700	2.300	0.800
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	11	150.000	54.000	73.091	150.000	78.000	61.000	59.000	54.000
00445 ANC CARB FET FIE (MG/L AS CO3)	11	0.000	--	--	--	--	--	--	--
00631 NO2 + NO3 DISSOL (MG/L AS N)	1	1.500	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	12	130.000	33.000	66.333	130.000	68.500	65.000	57.000	33.000
00915 CALCIUM DISSOLVE (MG/L AS CA)	6	39.000	16.000	22.333	39.000	26.250	20.000	16.750	16.000
00925 MAGNESIUM DISSOL (MG/L AS MG)	6	8.000	1.800	3.883	8.000	5.000	3.250	2.700	1.800
00930 SODIUM DISSOLVED (MG/L AS NA)	7	23.000	14.000	16.143	23.000	16.000	15.000	14.000	14.000
00931 SODIUM ADSORPTIO (RATIO)	5	0.900	0.800	--	--	--	--	--	--
00932 SODIUM, PERCENT PERCENT	7	36.000	1.000	23.143	36.000	33.000	31.000	1.000	1.000
00935 POTASSIUM DISSOL (MG/L AS K)	7	6.100	3.500	4.257	6.100	4.600	4.000	3.700	3.500
00940 CHLORIDE DISSOLV (MG/L AS CL)	12	23.000	15.000	19.083	23.000	20.750	19.500	16.500	15.000
00945 SULFATE DISSOLVE (MG/L AS SO4)	7	30.000	10.000	15.429	30.000	16.000	14.000	11.000	10.000
00950 FLUORIDE DISSOLV (MG/L AS F)	7	0.760	0.100	0.380	0.760	0.600	0.300	0.200	0.100
00955 SILICA DISSOLVED (MG/L AS SIO2)	3	61.000	42.000	--	--	--	--	--	--
01000 ARSENIC DISSOLVE (UG/L AS AS)	1	3.000	--	--	--	--	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	7	260.000	30.000	124.286	260.000	220.000	60.000	50.000	30.000
01046 IRON DISSOLVED (UG/L AS FE)	1	10.000	--	--	--	--	--	--	--
70300 RESIDUE DIS 180C MG/L	2	173.000	122.000	--	--	--	--	--	--
70301 DISSOLVED SOLIDS MG/L	6	202.000	115.000	162.000	202.000	182.500	164.500	141.250	115.000
70303 RESIDUE DIS TON/ T/AC-FT	5	0.270	0.160	--	--	--	--	--	--
71850 N, NITRATE TOTAL MG/L AS NO3	6	11.000	4.200	8.017	11.000	9.500	8.450	6.300	4.200
72000 ELEV.LSD(FT.AB.N FT (NGVD)	12	4440.000	4440.000	4440.000	4440.000	4440.000	4440.000	4440.000	4440.000

(Page 116) Example 8 Site 67--- STATION NUMBER: 352716115202901 STATION NAME: 015N015E59P001S
[Very deep well, bad quality, Ivanpah Valley area, from drilling by USGS geologist WR Moyle in 1969 & 70]
STATE: CALIFORNIA COUNTY: SAN BERNARDINO LATITUDE/LONGITUDE: 352716 1152029

STATISTICAL SUMMARY OF SELECTED WATER QUALITY DATA COLLECTED FROM MAY 1959 TO JAN 1970

	DESCRIPTIVE STATISTICS				PERCENT OF SAMPLES IN WHICH VALUES WERE LESS THAN OR EQUAL TO THOSE SHOWN				
WATER-QUALITY CONSTITUENT	SAMPLE SIZE	MAXIMUM	MINIMUM	MEAN	95 %	75 %	(MEDIAN) 50 %	25 %	5 %
00003 SAMPLING DEPTH (FEET	1	300.000	--	--	--	--	--	--	--
00010 WATER TEMPERATUR (DEGREES)	1	73.000	--	--	--	--	--	--	--
00095 SPECIFIC CONDUCT US/CM @ 25C	2	15400.000	8670.000	--	--	--	--	--	--
00400 PH, WH, FIELD (STANDARD UNIT	2	7.800	7.500	--	--	--	--	--	--
00405 CARBON DIOXIDE D (MG/L AS CO2)	2	6.900	4.100	--	--	--	--	--	--
00410 ANC, FET, FIELD (MG/L AS CACO3	2	135.000	112.000	--	--	--	--	--	--
00440 ANC HCO3 FET FIE (MG/L AS HCO3)	2	160.000	140.000	--	--	--	--	--	--
00445 ANC CARB FET FIE (MG/L AS CO3)	2	0.000	--	--	--	--	--	--	--
00900 HARDNESS TOTAL (MG/L AS CAO3)	2	2700.000	1200.000	--	--	--	--	--	--
00902 NONCARBONATE HAR (MG/L AS CACO3	2	2600.000	1000.000	--	--	--	--	--	--
00915 CALCIUM DISSOLVE (MG/L AS CA)	2	620.000	330.000	--	--	--	--	--	--
00925 MAGNESIUM DISSOL (MG/L AS MG)	2	280.000	83.000	--	--	--	--	--	--
00930 SODIUM DISSOLVED (MG/L AS NA)	2	3560.000	1560.000	--	--	--	--	--	--
00931 SODIUM ADSORPTIO (RATIO)	2	30.000	20.000	--	--	--	--	--	--
00932 SODIUM, PERCENT PERCENT	2	74.000	74.000	--	--	--	--	--	--
00935 POTASSIUM DISSOL (MG/L AS K)	2	51.000	23.000	--	--	--	--	--	--
00940 CHLORIDE DISSOLV (MG/L AS CL)	2	6200.000	1700.000	--	--	--	--	--	--
00945 SULFATE DISSOLVE (MG/L AS SO4)	2	1800.000	1400.000	--	--	--	--	--	--
00950 FLUORIDE DISSOLV (MG/L AS F)	2	0.800	0.300	--	--	--	--	--	--
00955 SILICA DISSOLVED (MG/L AS SIO2)	1	47.000	--	--	--	--	--	--	--
01020 BORON DISSOLVED (UG/L AS B)	2	950.000	400.000	--	--	--	--	--	--
70300 RESIDUE DIS 180C MG/L	2	12700.000	6100.000	--	--	--	--	--	--
70301 DISSOLVED SOLIDS MG/L	2	12200.000	5640.000	--	--	--	--	--	--
70303 RESIDUE DIS TON/ T/AC-FT	2	17.300	8.300	--	--	--	--	--	--
71850 N, NITRATE TOTAL MG/L AS NO3	2	100.000	5.500	--	--	--	--	--	--
72000 ELEV.LSD(FT.AB.N FT (NGVD)	2	2630.000	2630.000	--	--	--	--	--	--
72001 DEPTH OF HOLE IN FT	2	2240.000	2240.000	--	--	--	--	--	--